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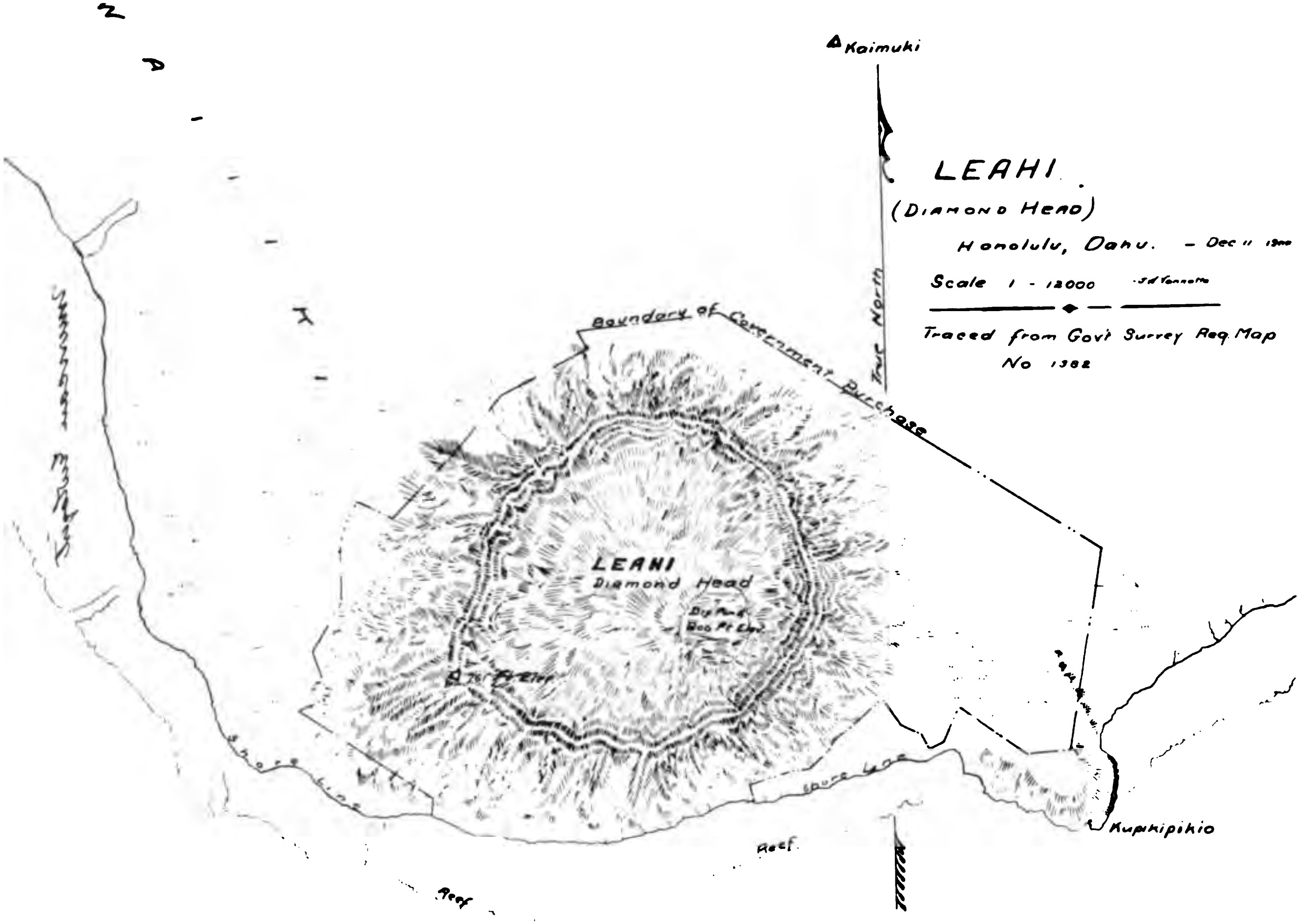

LEAHI.

(DIAMOND HEAD)

Honolulu, Oahu. — Dec 11 1900

Scale 1 - 12000

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THE

AMERICAN GEOLOGIST.

VOL. XXVII. JANUARY, 1901. No. 1.

BREVITY OF TUFF-CONE ERUPTIONS

By S. E. BISHOP, Honolulu.

PLATE I.

Tuff-cones, of which a number have been formed on the eastern coasts of the island of Oahu, are produced by the class of eruptions distinguished as " explosive." The semi-liquid tuff has been projected in a jet or fountain to a considerable distance and having been driven laterally by the expansion of the steam and other gases contained, has fallen at some distance from the vent, building up a cone with a more or less regular rim enclosing a concave bowl. All the explosive eruptions actually observed seem to have occupied a very brief time. The greatest one, that of Krakatoa, was probably less than one hour in actual emission, although the fall of its lighter ejecta continued for several hours.

It therefore seems remarkable that an opposite opinion should have been expressed respecting the eruption which produced Diamond Head. This typical tuff-cone, lying in the suburbs of Honolulu, bounds our ocean view to the eastward. It was recently examined by Doctor W. H. Dall of the Smithsonian Institution with especial regard to the age of the fossil shells found in its debris. In the "Bulletin of the Geological Society of America," Volume 11, pp. 57-60, Dr. Dall expressed conclusions respecting the age of the crater, which I feel obliged to controvert. He says:

"The conclusion to which I came was that the whole mass of Diamond Head had been slowly deposited in comparatively shallow water and gradually elevated without being subjected to notable flexure The ejection of material at first must have been intermittent with long quiescent periods to enable the shore to have become repopulated with mollusks and corals." A good picture of Diamond Head appears opposite page 40 preceding.

It is necessary here to remark upon two serious errors of observation committed by Dr. Dall. It is true that Diamond Head was deposited in shallow water, its center being about one mile outside of the previously existing shore line. I undertake, however, to question the idea that it has since been "gradually elevated." Such elevation if it occurred must have been some 200 feet to have exposed what he calls a marine formation on its seaward base. Dr. Dall should have observed the total absence of marine erosion around the sides of the cone, upon the soft material of which the action of the waves would have been extremely destructive There is also no trace of such erosion around the evidently older tuff-cone of Punchbowl, four miles away, nor any elevated beach marks along the neighboring mountains.

Dr. Dall's second error of observation was in attributing a marine origin to the mass of material lying against the seaward base of the crater. That mass is composed of mingled small angular fragments of tuff fallen from the hights above, with large quantities of calcareous beach sand. Pervading the mass are numberless laminated calcareous concretions, which Dr. Dall has mistaken for coral reef. These fragile laminated crusts are identical with those forming the interior structure of our numerous calcareous sand dunes. The layers constantly vary in angles of dip, corresponding to the formerly varying surfaces of the dunes. Had the tuff enclosed ever been exposed to the action of the waves, so far from retaining its angular forms, it would immediately have been ground into soft mud.

The whole mass is of Aeolian formation. It is simply a great sand-dune. The contents have been assorted by the wind, the eastern end being composed mainly of larger fragments of tuff, and the western end, one-third mile away, mainly of sand much triturated, and stained by the brown tuff. The mollusks of Tertiary age enclosed in the mass, as found by Dr. Dall, may be fully accounted for as having fallen from the hights with the tuff. They were torn off from the ancient submerged reefs and beaches traversed by the shaft of the eruption. I have found large shells embedded in the laminated tuff at Koko Head, as well as corals. Farther evidence is found in the fact that fragile land mollusks are enclosed between the crusts in great numbers side by side with the marine shells. Both fell together from the cliffs above.

My main contention, however, is to prove the absolute impossibility that a crater like Diamond Head should be a product of "intermittent ejection" with "quiescent periods," even brief ones, or that it could have been "slowly deposited." I propose to prove that a cone of such peculiar form and structure could have been created only by an extremely rapid projection aloft of its material, completed in a few hours at most, and ceasing suddenly and finally.

My first proof of this conclusion is derived from the extreme regularity of the elevated circular rim of this cone, such as could be the result only of a single, rapid, uniform, unintermitted outthrow of the tuff. Two-thirds of the elevated perimeter is part of an almost perfect circle of about 5,000 feet in diameter, and of a comparatively uniform hight, about 450 feet above sea-level. The tuff is piled up in this regular ridge, originally rounded on its top, in very uniform quaquaversal layers or lamniae, whose steepest dip on the outside is about 35°, and much less on the inside of the broad bowl. The great subaerial erosion discloses the interior structure of the rim, although it has not obliterated the really delicate symmetry of the original form. (See Plate 8, Vol. 11, p. 46.)

The southwest third of the perimeter of the crater is massive, attaining a present hight of 762 feet. It is severely wasted by the impact of storms, and was once probably 1,000 feet high. The original rounded summit must have been considerably to seaward of the present sharp peak. The original form may be best understood by comparison with those of Koko Head and of Lehua island, which are of somewhat similar form and dimensions, but remain substantially unaltered in their rounded summits. The immense enlargement of the southwest portions of these craters, as well as of many others is doubtless correctly attributed by W. L. Green to the action of the strong trade winds deflecting to leeward the lofty jet of tuff, and piling it up disproportionately on that side.

With due allowance for the single disturbing influence of the wind upon the summit of the mighty fountain, it is evident that the very perfect symmetry of the main portion of the rim could have been produced only by an extremely regular fall of the spreading fountain of ejecta at a uniform and unvarying distance from the vent. Any interruption or intermission would have so disturbed that precise uniformity of projection as to have piled the falling tuff in irregular positions. The beautiful symmetry of the crater is a powerful witness of its sudden and rapid formation. It forbids any other conception.

My second evidence of the brevity of the eruption which created the crater-cone is derived from an arithmetical computation of the time required to deposit the actual mass of the cone by a fountain of adequate hight to deliver its ejecta upon the existing rim of the bowl. Data are easily secured for a sufficiently approximate estimate of the time to show that it could have occupied a very few hours at most. Let us first compute the solid contents of the tuff deposited. The average diameter of the bowl is about 5,000 feet. Two-thirds of the perimeter is 450 feet high, to which 50 feet may be added on account of the average depth of sea at the distance from the shore where the eruption occurred. The other third of the perimeter was occupied by a conical mass probably 1,000 feet high, but standing in perhaps 250 feet depth of sea. Estimating this cone as 1,250 feet high, with 5,000 feet diameter of base, its solid content would be about 8,000,000,000 cubic feet. The contents of the other two-thirds of the perimeter would be about 5,000,000,000 feet, making with the cone a mass of 13,000,000,000 cubic feet of tuff in the entire crater.

A similar result is obtained by assuming a base equivalent to 5,000 feet square, and an average hight of 500 feet, which gives a solid content of twelve and a half billions of cubic feet. It is evident that such an estimate is sufficiently large.

Now, to have ejected the whole mass in five hours would have required an emission from the vent of two and a half billions of cubic feet of tuff in an hour, or of 694,444, feet in one second. Supposing the vent to have a sectional area of 2,000 feet, which I believe to be much too small, the velocity of emission would be only 347 feet in a second, which is equiva-

lent to a theoretical hight of only 1,900 feet of projection al
It is evident that this is totally inadequate. Assume then
two hours' duration of the eruption. This gives us 875
velocity of emission, equivalent to a hight of projection
11,925 feet. Such an altitude of the fountain might be adequate to the actual distribution of the ejecta to an average distance of 2,500 feet from the vent. But it must be noted that the hight attained with the assumed velocity could hardly be more than two-thirds of the theoretical one, on account of the resistance from the falling tuff encountered by the ascending jet. It is also evident that the fountain must have been a very lofty one for the tuff to have been driven half a mile to the leeward by even a heavy gale, as so much of it was done in building up the massive cone.

The real area of the vent can be less accurately estimated. The partially exposed vent of the neighboring crater of Punch Bowl is apparently fully a hundred feet in diameter. The only completely open vent of the kind which I have seen is that of Kalaupapa at the leper settlement on Molokai. This is a rocky well with vertical sides reaching down to salt water, which is 800 feet deep. The diameter of this well or shaft was, as I remember it, from 100 to 150 feet. Guided by these data I should consider 5,000 square feet as a very conservative estimate for the sectional area of the shaft from which issued the tuff of Diamond Head, instead of the 2,000 feet assumed above Such increased area would reduce the two hours' duration assumed, to 48 minutes. It would be much less if we allow a greater velocity of ejection, so as to get a hight of the fountain adaquate to allow of its extensive deflection by wind. I incline to the belief that the eruption did not last more than half an hour. It is absolutely impossible that it could have continued many hours.

These explosive eruptions are of gigantic force and brief duration.

Honolulu, November 14th, 1900.

POSSIBLE NEW COAL-PLANTS ETC., IN COAL.

PART III.

By W. S. Gresley, Erie, Pa.

Plates II-VIII.

Reference to and Remarks on the Figures in Plate II.

Fig. 1. Portion of a cluster or patch of seed-like bodies, partly in plan and partly in section, embedded in a fragment of ordinary commercial anthracite (Carboniferous) from Pennsylvania. The name or number of the vein or seam, as well as location, is not known.

Fig. 2. Horizontal section of one of the objects—pods or seeds (? megaspores) in fig. 1. In reality the spotted aspect of the contents of these black-bordered bodies should be spoken of as clear, black, compact anthracite as a matrix to hundreds if not thousands of minute gray specks.

Fig. 3. Magnified appearance of the ? microspores—seed contents—of these little ? pods.

Remarks on the foregoing. Whatever these fructifications represent they appear to be oblong in form rather than circular. Along the lower right and along the bottom of the specimen the pods are seen in oblique section, on account of the breaking of the coal. Since the blank area "a" shows a different horizon in the coal from that in which the fossil reposes, it is quite reasonable to suppose that the seeds lie beneath it, and not less closely packed than seen higher up in the fig. near "b." Is there not in the pose of these bodies a suggestions of symmetry in form or arrangement, as opposed to a disposition resulting from scattering or accidental accumulation. While the various pods are not seen to possess connection by stalks, there is nevertheless among them indication of such in the shape of coaly filamentose appendages or inter-twinings suggesting that the fossil represents seeds syncarpous in form rather than individually scattered or accidentally buried here in a mass together. In this fossil I see nothing to suggest a cone-derivation for these spores. May they not have belonged to a water plant?

Other, but smaller and less preserved specimens of very similar seeds have been met with in the same coal; the exact

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*For earlier papers of this series see American Geologist, Feb. 1899, Oct. 1899, and July, 1900.

ASTOR, LENOX AND
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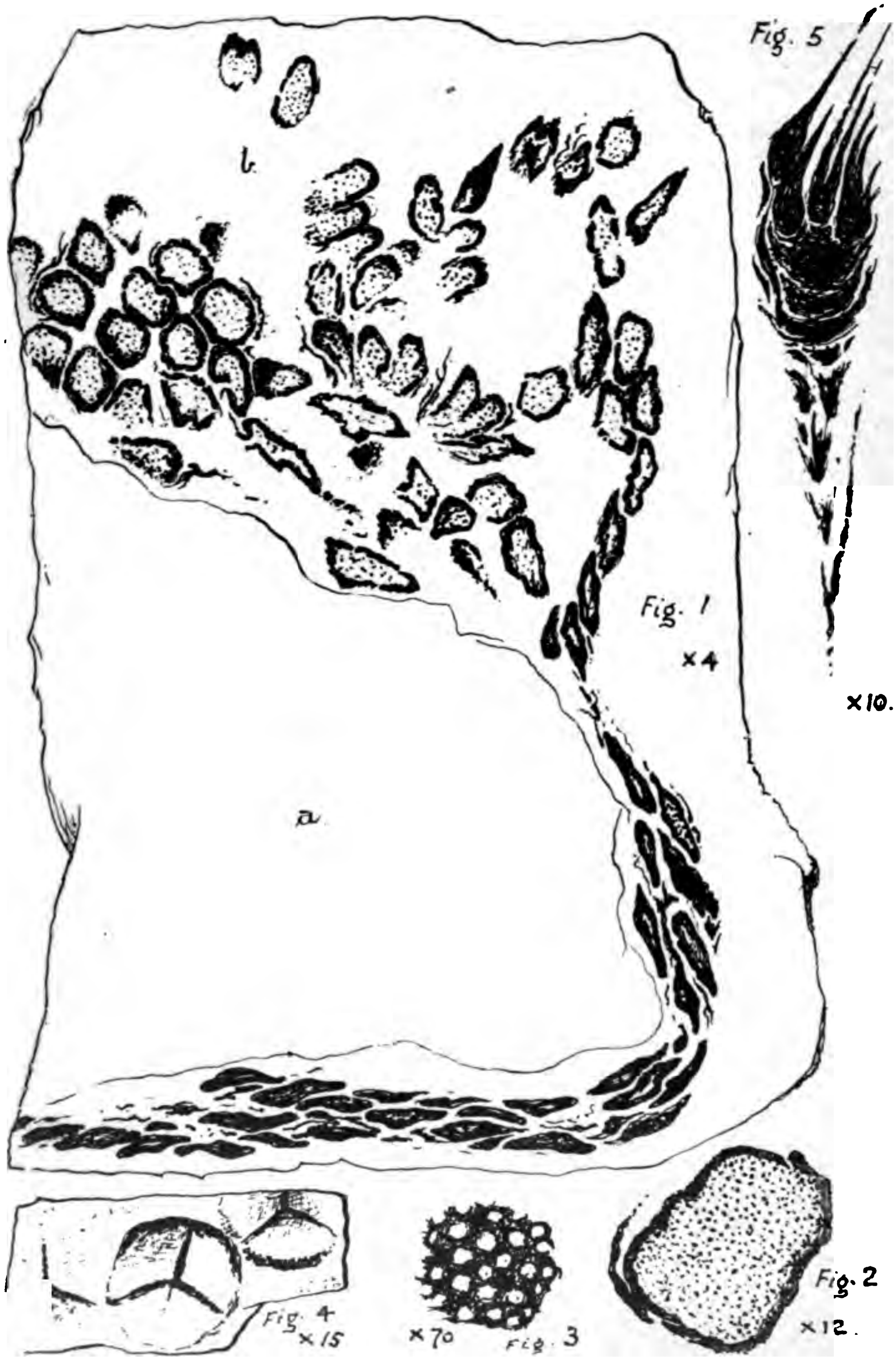
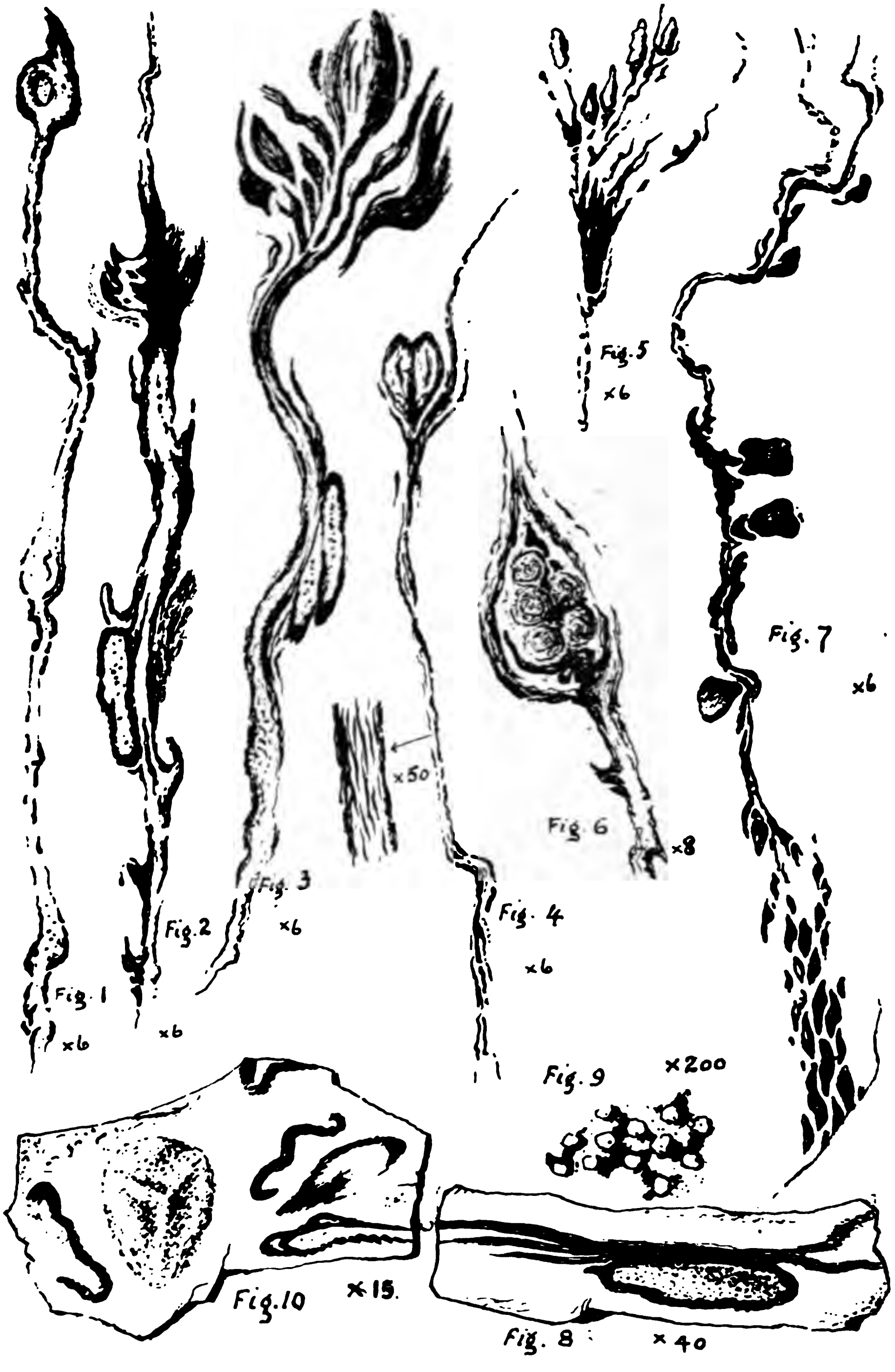


STRUCTURES IN COAL.

ASTOR, LENOX AND
TILDEN FOUNDATIONS.



STRUCTURES IN COAL.

character of the enclosing material, being rather dull and gray, or "bony," than black or more glossy coal.

Notice how easily the lower part of the specimen fig. 1 might be mistaken for the form illustrated in fig. 3, plate II, facing p. 50, vol. xxvi, July, 1900.

Fig. 4. Vertical view showing a patch of ? detached or scattered *tri-radiate* spores,? occurring in coal same as fig. 1.

Fig. 5. Longitudinal section, ? somewhat oblique, apparently exhibiting a small cone or inflorescence belonging to some unknown plant embedded in a dark gray lamina of Pennsylvania anthracite.

Reference to plate III and remarks on the specimens.

Figs. 1 to 7. Horizontal, or for the most part horizontal, sections of various pods, seeds, infloresences etc., of several kinds attached to or in such close contact with parts of stalks, twigs or other extremities of plants that they are probably *in situ*. Observed upon the planes of lamination of various specimens of Pennsylvania anthracite.

Fig. 8. Oblique section of a comparatively small ? macrospore, apparently attached at the junction of ribbon-shaped processes. Pennsylvania anthracite.

Fig. 9 Magnified aspect of some of the ? microspores of the form fig. 8.

Fig. 10. Exterior of macrospore ? (in this case composed of pyrite) embedded in anthracite; associated with several other [illegible] seen [illegible]

[illegible] If we admit that [illegible] the most [illegible] fossils are fragmentary all that [illegible] can [illegible] we seem to be presented with some [illegible] different species of seeds and ovules as the case [illegible] seem to belong to cones but rather [illegible] branching [illegible] drawings may serve [illegible] direct the [illegible] to similar forms so that eventually [illegible] near. Since [illegible] quite crowded with [illegible] they belonged [illegible] as to their substance

Reference to [illegible]

Fig. [illegible]

bedding plane of coal-seam (bituminous). *Loc.* What Cheer, Iowa.

Fig. 2. Tri-radiate macrospores? with leafy expansions apparently torn and fragmental. Color, pale brown. Same horizon and same locality as specimen fig. 1. (See *"Triletes,"* Kidston, in Trans. Roy. Soc. of Edin.; vol. 35, p. 63.)

Fig. 3. A pear-shaped seed—exterior view: seems to be made of coal. Same horizon and locality as specimens fig. 1 and 2. (Similar or very similar forms had been noticed by me in the "Pittsburg" coal bed, Pa., and in the "Barnsley Thick" coal in Yorkshire, England.)

Fig. 4. A flattened fruit or seed? *Cardiocarpon* consisting of coaly material.

Horizon and locality same as the above.

Fig. 5. A three-cornered seed or pod, fossilized it would seem when about to open along tri-radiate lines. Composed of lime etc., and found in a concretion of that material with pyrites, in the coal bed of What Cheer, Keokuk county, Iowa.

Fig. 6. Nearly horizontal section of what appears to be a pod filled with seeds. Composed of black carbonaceous material and pyrite. *Horizon.* Coal bed. *Loc.* What Cheer, Iowa. (Discovered by grinding and polishing the material.)

Fig. 7. Horizontal view of a little patch of moss-like filaments (blackish in color, and embedded in pyrite), enclosing brown seeds. *Locality*, the coal bed at What Cheer, Iowa.

Fig. 8. Horizontal section or view of part of some plant, in or upon the parts of which are seen little, bright, yellowish, red-coated seeds, having pearly white nuclei more or less visible. This and the form illustrated in fig. 7, may be the same plant. Found in a lime and pyrite concretion in the coal at What Cheer, Iowa.

Fig. 9. Horizontal section (developed by grinding and polishing a fragment of a pyrites nodule taken out of the coal at What Cheer, Iowa) of a seed-bearing inflorescence. *a.* shows a [illegible] ovule (or epicarp?), to all appearances in place in the fructification. The specimen seems to be bractiform [illegible]. The material of the epicarp? is of a brown [illegible]. Other points of interest in this specimen may be [illegible] the drawing.

Fig. 10. [illegible] view of the specimen of what seems to be a [illegible] perhaps similar to the [illegible] specimen was not found *in situ* [illegible] scattered, but in the same [illegible] the testa or pericarp. [illegible] the seed; b. mem- [illegible] excrescences, [illegible] the nucleus or seed; [illegible] of the seed itself.

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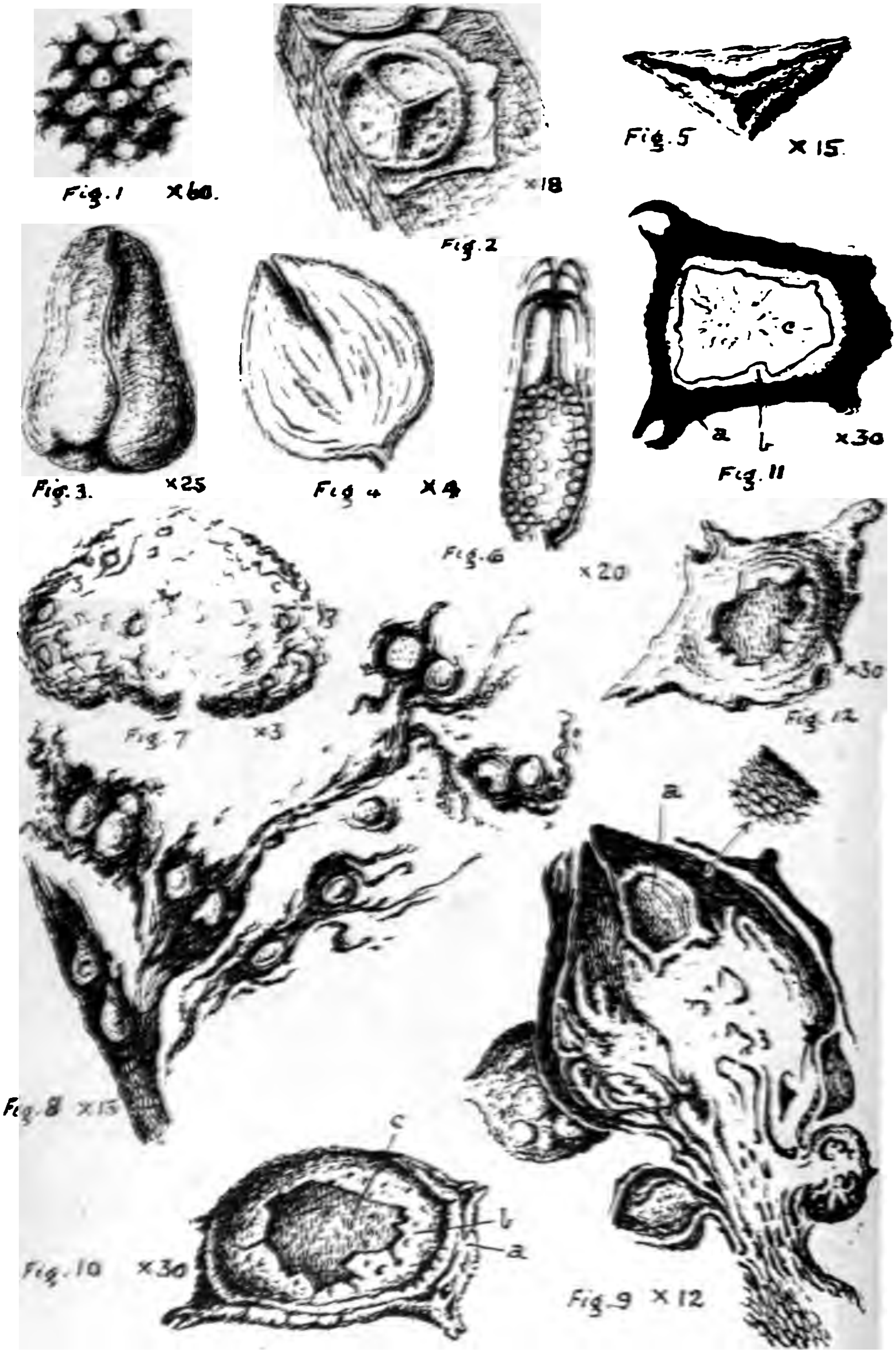

SEEDS ETC.. IN COAL

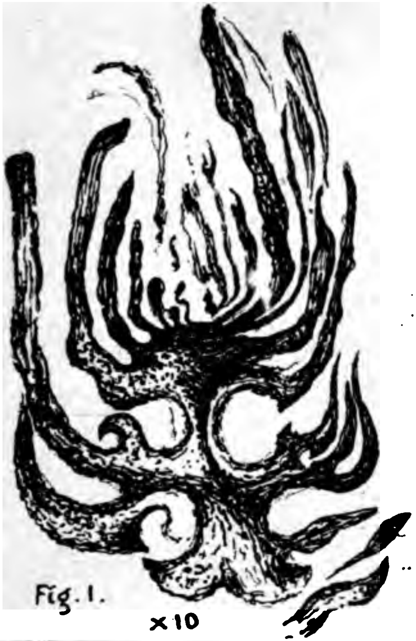

Fig. 1. ×10

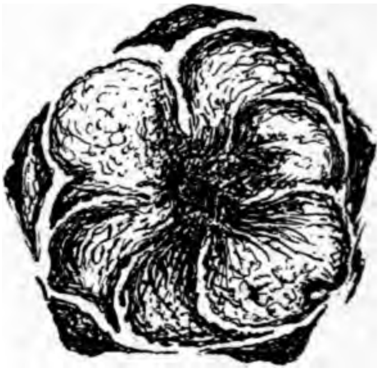

Fig. 3 ×12

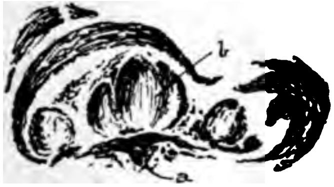

Fig. 6 ×12

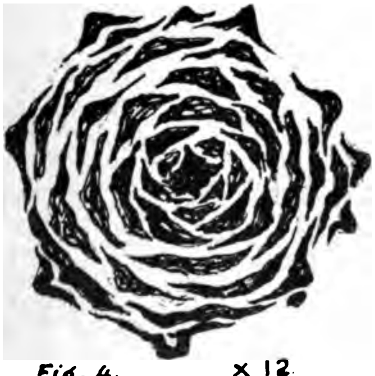

Fig. 4. ×12

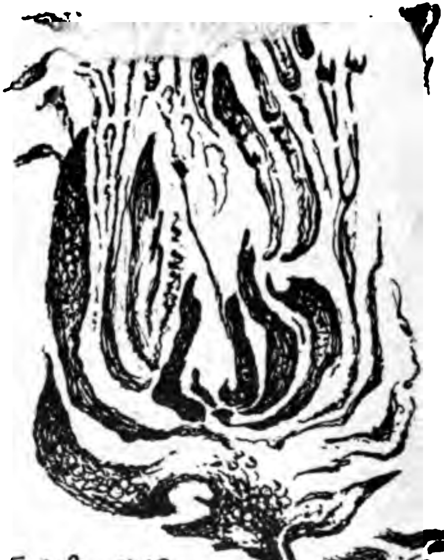

Fig. 2 ×12.

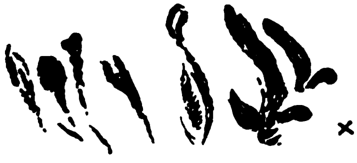

Fig. 5 ×20

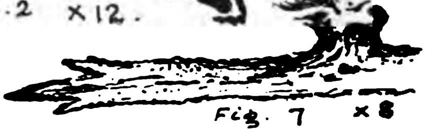

Fig. 7 ×8

INFLORESCENCE IN COAL.

which is, I think, globular in form, peeping through the broken envelope *b*. The substance of *c* is beautifully pearly white, or of a pale resinous hue, and presumably is petrified albumen or endosperm.

Fig. 11. Seed, very similar to that in fig. 10, and in the same or a similar pyritous nodule in the What Cheer coal bed. Developed by grinding and polishing. Shows flocculent, cloudy white, central or nucleal material *c*: golden colored membrane *b;* horned and 4-cornered testa or pericarp *a*.

Fig. 12. External aspect of another seed very like the one in fig. 10, but probably a less perfect specimen as to the outer envelope, one of the 4 corners seems to be broken off. Here again is seen the pearly-looking nucleus where the coverings have been removed.

These seeds are, in the What Cheer coal material, associated with *Lepidodendron,* (?) *Sphenophyllum, Myclopteris,* and the other forms herein illustrated, e. g. *Cardiocarpus,* [illegible]

[illegible] eer coal bed is, by the state geo-
[illegible] near the base of the coal meas-
[illegible] *stage* of the Carboniferous. (See
Iowa [illegible] l. IV. Third Annual Report, 1894,
pp. 225-311.)

The pyritous concretions in the What Cheer coal furnish us with samples of what may be called the *raw material* of coal saved from coalification by these concentrations of iron, sulphur, lime, etc.

Reference to Plate V. and Remarks on the Specimens.

Fig. 1. Longitudinal section, developed by grinding and polishing a fragment of a pyritous concretion, of a small bractiform inflorescence. *Locality*. What Cheer, Iowa.

Fig. 2. Longitudinal section of another very similar form, possessing stamens *in loco natali*. From same material, same coal-bed, and same locality as specimen fig. 1. Does not this specimen suggest a male flower showing pollen sacs? Attached to the stalk of this fossil were two other very similar flowers (if flowers they can be called), one on each side and about one-eighth of an inch below it. The stalks, however, were very poorly preserved, no structure was observed in them.

Fig. 3. Transverse sectional aspect of one of these cones, very close to its base.

Fig. 4. Transverse section—polished, of one of these cones from the coal in Iowa.

Fig. 5. Illustrations of stamens, or the ? *calyptra* of the same, in another specimen of the same inflorescence.

Fig. 6. Longitudinal section through the central part of a cone showing several barren ? seed-vessels *b* at the top of the stalk *a*.

Fig. 7. Longitudinal section of a fragment of a twig or branch showing indications of the peduncular attachment belonging to one of these inflorescences. The form of one twig seems to have been deeply grooved longitudinally, and was perhaps of hexagonal section.

Reference to Plate VI. and Remarks on the Fossils.

Fig. 1. View of a group of small conical forms, some attached to the stalk and branch, as exposed by fracturing a mineralized nodule (pyrite, lime, etc.) taken from the coal at What Cheer, Iowa. In this specimen the stalk consists of a softish, brownish black material and exhibits no organic structure. In close touch with these cones were several nuts of *Cardiocarpus* (Plate VII).

Fig. 2. Longitudinal section of a cone?, and a cluster of what looks like three seeds within bractiform envelopes; both objects are attached to the badly-preserved twig. From the same pyritous concretions in Iowa coal.

Fig. 3. Longitudinal and rather oblique section of the terminal of a branch or twig, bearing what appears to be a damaged inflorescence at *a*. Brought to light by grinding and polishing the pyritous material out of the coal in Iowa.

Fig. 4. Transverse section through the lower part of the twig fig. 3, showing leaves surrounding the twig or branch, of which there seem to have been about ten to each node.

Fig. 5. Longitudinal section of what appears to be a terminal of some twig belonging to still another plant.

Fig. 6. Longitudinal section of part of a seed bearing ? twig of possibly still another species.

All of the above specimens were discovered in the pyritous nodular concretions out of the coal-bed at What Cheer, Iowa.

Reference to Plate VII. and Remarks on the Specimens.

Fig. 1. Longitudinal sectional view or diagram, compiled from several different specimens, of a *Cardiocarpus*—(cardiocarpon fruit). The right half of this fruit, seed, or nut, from the line *a b* is wholly sectional, and shows indications of bracts or leaves *c* enclosing or partly surrounding the exotesta *d*. Between the latter and the perispermic membrane? is a zone of calc-spar *f*. *g* is the nucleus—the endosperm, consisting of milky white calcareous material, and exhibiting a beautiful radiate flocculent structure by a paler tint per-

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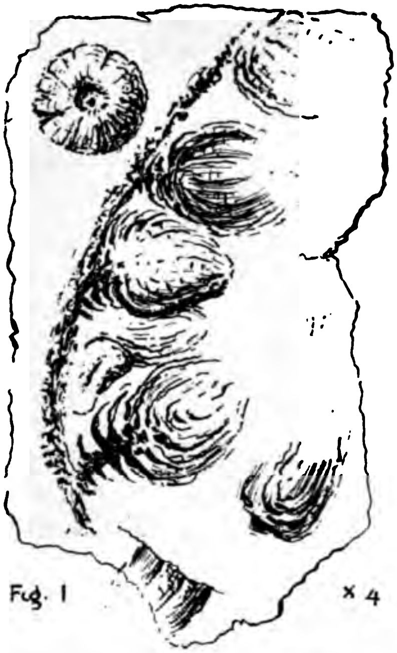


Fig. 1 × 4

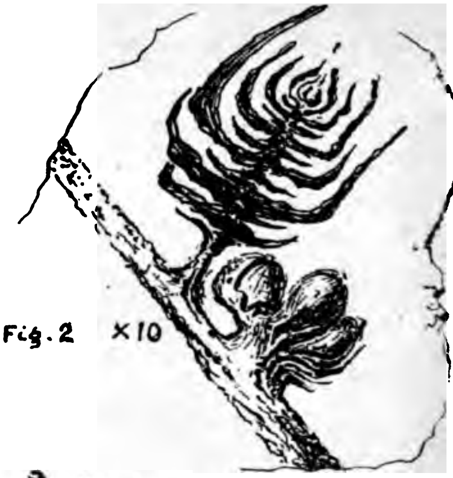


Fig. 2 ×10

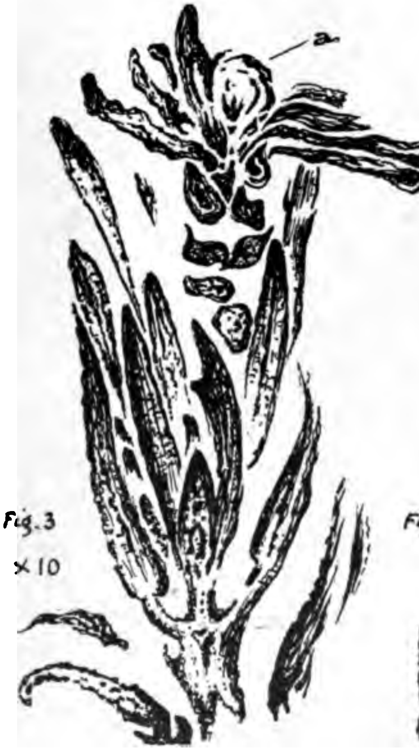


Fig. 3 ×10

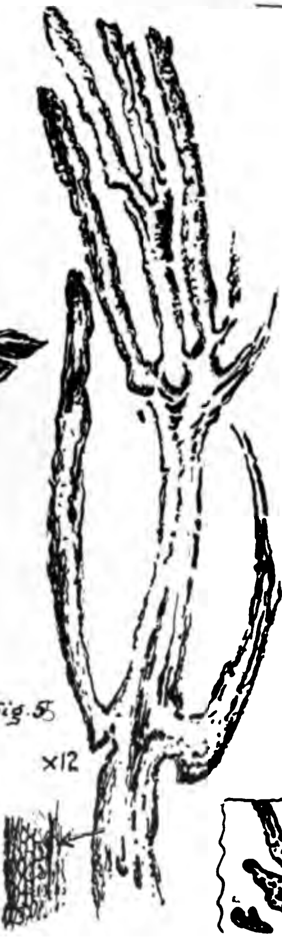


Fig. 5 ×12

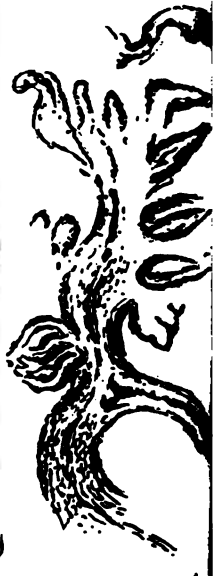


Fig. 6 ×6

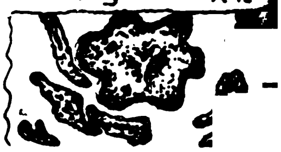
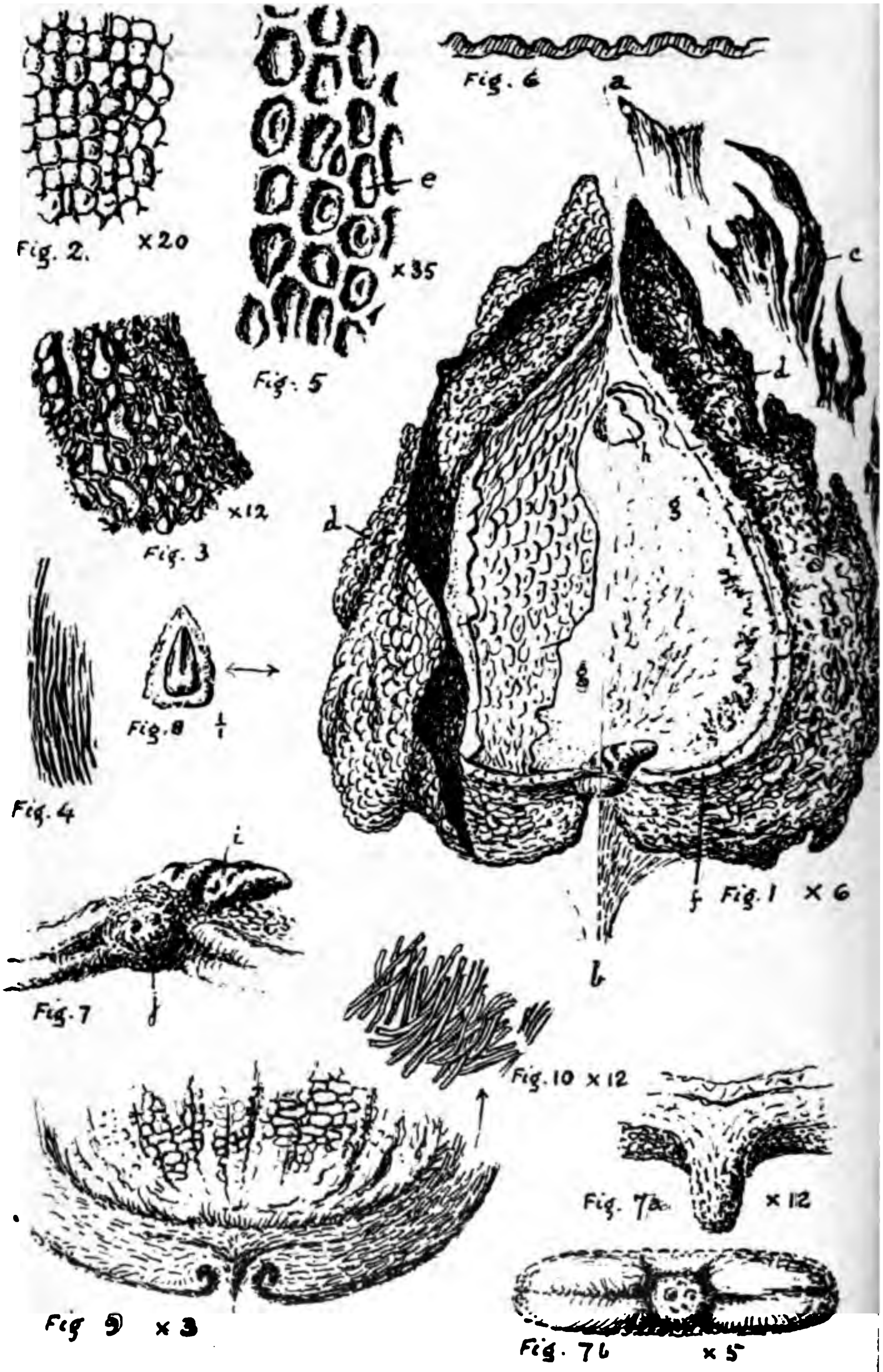


Fig. 4 ×15

CONES ETC. IN COAL.



CARDIOCARPUS IN COAL.

vading the more cloudy one. Near the exterior of the nucleus are beautiful plays of microscopic aborescent pyrite, which wave about and creep inwards or towards the center of the seed. There are near the apex of *g*. certain yellowish brown inclusions or formations *h*, that may suggest an embryo. At the base of the seed may be noticed several interesting structural features pertaining to the peduncle.

The left hand half of the figure shows a portion of the exotesta removed so as to bring into view the aspect of the membrane fig. 5, and beneath this membrane at *g* the surface of the kernel or seed itself appears, which surface is marked or bears the impress of the pattern or formation suggested by the drawing fig. 5—the membrane *e*. Observe the rugged exterior of the outer envelope *d*. In some specimens this is seen to be broken and displaced, suggesting something harder than a fleshy composition.

From mineralized nodules in the coal bed at What Cheer, Iowa.

Fig. 2. Pattern or quasi tessellated appearance of the exotesta *d* fig. 1. The color of it is golden brown to greenish gold—has a bronzy aspect.

Fig. 3. Suggests the character of the substance or structure of the exotesta *d*. In color is grayish, but often mottled or variegated—black, white, gray, brown, yellowish and reddish. Near the sides the cells become smaller.

Fig. 4. Hairy aspect of the inner surface of the exotesta *d*: greatly magnified.

Fig. 5. An attempt to depict the pattern or moulded form of the membrane or thin envelope in contact with the endosperm *g*. In substance this membrane is very brittle, thin, and of a golden brown color. Where the kernel *g* is widest the pattern is best developed; as the micropyle is approached the pattern is elongated, contracted and narrowed down as indicated in fig. 1. In reality this pattern consists of little ovoid knobs within little ovoid depressions.

Fig. 6. Transverse section of the membrane *e*, so far as showing its corrugations.

Fig. 7. Oblique view of part of the base of this *Cardiocarpus*, showing the hilum *j*, and what is perhaps a radicle or caulicle *i* protruding into the nucleus *g* fig. 1. This radicle?, or whatever it is, is colored golden brown outside, and its interior substance is white. Does this feature indicate two cotyledons?

Fig. 7. a. Longitudinal section of another aspect of the base or near to the base of this or another species. I do not understand it.

Fig. 7. b. View of the base of the nucleus g, fig. 1: ? the hilum.

Fig. 8. Longitudinal section, end view, of one of these specimens of *Cardiocarpus*.

Fig. 9. Longitudinal section of part of possibly a different species of *Cardiocarpus*. This specimen, being badly squeezed or preserved, is difficult to understand. It seems to have possessed a fibrous exotesta, the character of whose tissue, being pulled apart, is shown in fig. 10. The pattern on the inner envelope, and some structures near the peduncle are indicated. This fruit was about twice the size of the *Cardiocarpus* fig. 1. Same horizon, locality and material as for specimens figs. 1 to 8.

I am not aware of any *Cardiocarpus* showing more internal organization than do these from the coal of What Cheer in Iowa, and so possibly they may aid in settling the still open question—were *cardiocarpa* seeds?

Though the nodules were quite rich in numbers of the fruits figs. 1 to 8, I failed to detect any of them attached to stalk or twig. They lay in the matrix in all positions and scattered; evidently dropped upon or into the vegetable material enclosing them; in some cases they were in actual contact with the inflorescenses, Plate V, and with forms shown in Plates VI and VIII.

To facilitate reference to authorities on *Cardiocarpus*, the following are given:

Q. J. G S., vol. xxviii, plate 27, fig. 4. (an Australian specimen).

Manual of Palaeontology, by A. Nicholson, vol. 2, p. 450.

Cat. Palae. Plants in the British Museum, by R. Kidston, 1886, p. 207.

Report of the Second Geological Survey of Pennsylvania, vol. P, (Atlas, *Coal Flora*) pp. 561-574, plate lxxxv, figs. 32-50, and plate lxxxvii, fig. 8.

Palaeontological Botany, by J. H. Balfour, 1872, pp. 65, 66.

Fossil Botany, by Solms-Laubach, 1891, p. 118.

Text-book of Geology, by A. Geikie, 1882, p. 731.

Geological History of Plants, by Sir J. W. Dawson (1888), pp. 80, 82, 153.

Acadian Geology (second edition), by Sir J. W. Dawson (1868), pp. 459, 460.

Geological Survey of Ohio (Palæntology, vol. 1), by J. S. Newberry, 1873. Plates xli, xliii.

Geological Mag., 1872, vol. ix, pp. 55, 57.

Phil. Trans. Roy. Soc. Fossil Plants of the coal measures, part viii, by W. C. Williamson, 18 May, 1876, plates xiv, xv, and xvi.

Reference to Plate VIII. and Remarks on the Specimens.

Fig. 1. Fragment of a small *Pecopteris*, shown more or less in diagram, indicating the form, the shape and disposition of the pinnæ, with the exterior venation on the right, and some

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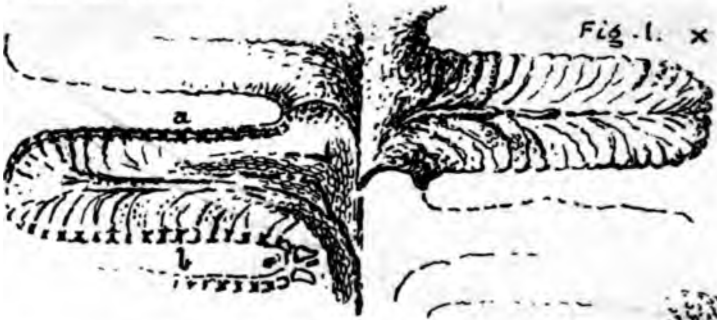

Fig. 1. × 6

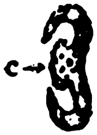

Fig 2 × 6

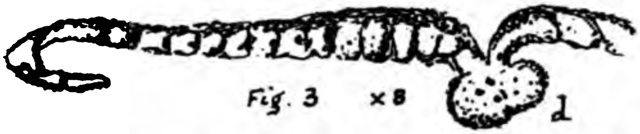

Fig. 3 × 8

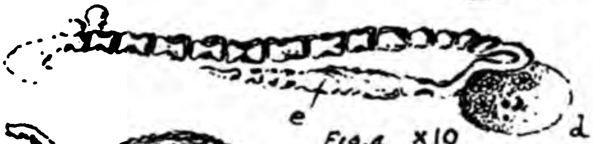

Fig. 4 × 10

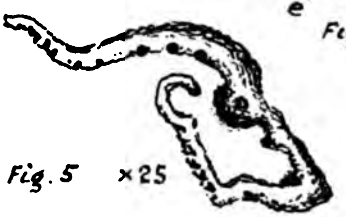

Fig. 5 × 25

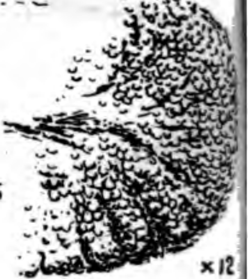

Fig. 6

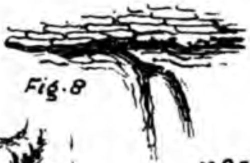

Fig. 8 × 25

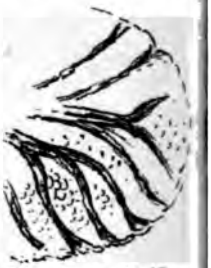

Fig. 7 × 12

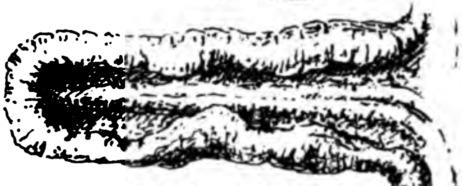

Fig. 9 × 8

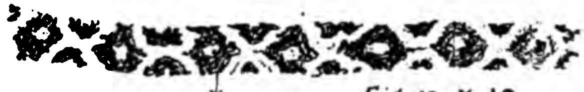

Fig. 10 × 10

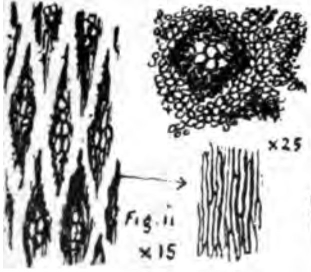

Fig. 11 × 15

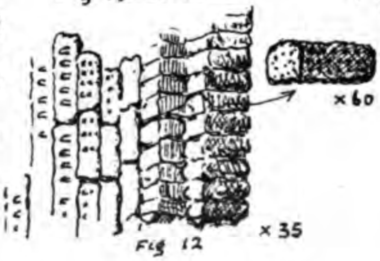

Fig 12

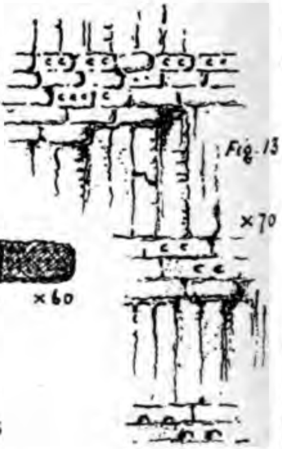

Fig. 13

PECOPTERIS ETC. IN COAL.

anatomical structures on the left. From pyrites nodule in the coal at What Cheer, Iowa.

Fig. 2. Transverse section of a pinna through *a b* fig. 1, showing curling under of the rim or sides of the pinnæ, and the position, shape and size of the mid-rib *c*.

Fig. 3. Longitudinal section through a pinna, near the curving-under line (*c* fig. 2), showing cross section of the branching venation, the curved-under point of the pinna, and the stalk of the frond at *d*.

Fig. 4. Another long section of a pinna between its mid-rib and the curving-under line, showing frond's mid-rib *d*, and the curved-under edge of the pinna *e*.

Fig. 5. Rather oblique cross section of a pinna, showing curiously curved form.

Fig. 6. The aspect of the exterior or upper surface of a pinna.

Fig. 7. Details of the venation near the tip of a pinna.

Fig. 8. Longitudinal section of part of a mid-rib, with branching or rebranching venation and associated cellular structure.

Fig. 9. View of the underside of a pinna (restored).

Note. In these pyrites concretions in the coal bed at What Cheer in Iowa, this species of *Pecopteris* is rather common. It was by grinding and polishing that the structural details were brought to light, and I am greatly indebted to Dr. David White of the United States Geological survey for suggesting that this fossil be figured, because probably of scientific value paleobotanically. Instances of fossilized anatomical structures in the leaves of ferns are certainly very rare, in fact this is about the only case I can find or know of.

Fig. 10. Transverse section of part of one of the What Cheer nodules, showing a portion of a row of pyrite-colored XXX and dots, separated by or embedded in a blackish substance.

Fig. 11. The aspect of the specimen fig. 10 after grinding and polishing obliquely. The material was evidently vegetable. and the structures seem to suggest the palm or the cane.

Fig. 12. Fragment of mineralized cellular vegetable material (chiefly pyrite), showing pitted and punctate vessels of two or three kinds. From the coal bed at What Cheer, Iowa.

Fig. 13. Coniferous? wood-cells and medullary ray? material, composed of pyrite etc., in the coal of What Cheer, Iowa.

Note. The surfaces of these What Cheer pyritous nodules, while preserving a generally regular outline or contour, are in reality anything but smooth—they are decidedly rough; the pyrites mixed with the coal laminæ of the seam, and the coal on the other hand penetrates the pyrites.

And in regard to the well-preserved condition of the vegetable contents of these concretions. it would be very interesting to know, could the point be determined, whether this vegetable matter passed through the coaly state between that of the wood, leaves, seeds, etc., and the pyritous condition—to stone; or whether the wood, seeds, etc., passed direct into stone *pari passu* with the process which converted the vegetable matter that is now the coal into coal. And this thought leads to another, viz.: Are the same fossils in the coal as we find in the concretions? The ragged surfaces of the concretions and the aspect of the fossils where they terminate on these surfaces (sometimes they grade into coal) suggest an answer in the affirmative. But be this as it may, the phenomenon which these nodules reveal, of so much uncrushed or apparently loose-lying vegetable tissues and structures as they do, shows with what intricate subtle and complex processes and ways the conversion of the vegetable matter of the Carboniferous period into coal, and petrifactions in the coal, was in all probability attended.

Physically and stratigraphically it is interesting to find, as I have done, the following familiar forms either in or upon this particular bed of coal; which indicate accumulation of the vegetal material under marine rather than fresh water conditions: *Discina, Natica?, Pentamerus, Lingula, Terebratula, Pleurotomaria?* and *Orthoceras.*

ON THE PETROGRAPHY OF MOUNT ORFORD.

By John A. Dresser, Richmond, Quebec.

The Green mountains of Vermont enter the province of Quebec in several ranges which run in parallel courses and have a general northeasterly direction, varying in elevation from inconspicuous hills, or ridges, to mountains upwards of 3,000 feet in hight. One of these ranges, which is a continuation of that to which Jay peak belongs in Vermont, forms the Sutton mountains; another, appearing first at some distance on the east side of lake Memphramagog, becomes the Stoke range, and is a more noticeable feature of the landscape farther towards the northeast, where it has a greater elevation;

a third forms the line of hills along the international boundary line between the states of New Hampshire and Maine on the one hand and the "eastern townships" of the province of Quebec on the other.[*]

A little to the east of the Sutton ridge and parallel to it there is for some distance north of the Vermont boundary line a series of irregular hills, which have a quite different origin from the ranges on either side of them. While the latter have been produced chiefly by the crumpling and folding of sedimentary strata the former are of volcanic origin, being the remains of immense outputs of lava, now greatly altered in character and reduced in amount, which were ejected from a series of volcanoes or fissure eruptions, probably caused by the weakening of the sedimentary strata in the process of the folding which produced the Sutton mountains.

The largest of these igneous masses is that which comprises mount Oxford, the area of which is not less than twenty square miles. If its average hight above the surrounding country be estimated at 1,000 feet,[§] the mountain at present represents four cubic miles of lava which have been extruded in this one mass, and it must also be remembered that a considerable portion of the mountain has doubtless been removed by denudation, for besides the action of subaerial agencies, it has also suffered from glaciation, even upon the summit.[†]

The densely wooded nature of the mountain as well as its precipitous sides in the only practicable direction of approach make the mountain difficult of access and render a detailed field examination at present impossible. Yet well known paths of ascent on the southern side give almost continuous exposures from the Canadian Pacific railway at the base to the summit, while, as has been pointed out by Dr. Ells,[‡] a unique section is exposed by the cutting of the railway which skirts the base of the mountain between Milton and Eastman, in a direction normal to the axis of folding as well as to the strike of the adjacent sedimentary rocks. On the whole, however, any observations that can yet be made on the larger petrographical relations of the mountain must still be regarded as of a preliminary nature.

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[*] Dr. R. W. Ells. *Rep. Geological Survey of Canada*, Vol. II, 1886, Part J. and map, and Vol. VII, 1894, Part J. and map.

[§] The Canadian Pacific Railway at Miletta Station is 905 feet above mean sea level. P. Alex. Peterson, Chief Engineer, C. P. Ry.

Dr. Ells (op. cit.) found the height of the summit to be 2800 feet above sea level by aneroid measurements which were subsequently corroborated by Mr. Chalmers. (*An. Rep. Geol. Survey of Canada*, Vol. X, Part J.

Messrs. Evans and Leroy (*Can. Rec. Sci.* pp. 225-7, July 1900) find the total elevation somewhat less, viz: 2650 feet.

[†] *Can. Rec. Sci.*, July 1900, pp. 223-5.

[‡] *An. Rep. Geol. Survey of Canada*, 1894, Part J., pp. 59-62.

The rocks of Shefford mountain comprise two main divisions. The first, which is found on approaching the mountain from the eastern side, i. e., along the railway from Milton station, and which is intrusive through Cambro-Silurian strata, constitutes much the greater part of the mountain and is an igneous rock of rather uniform character, probably the product of a single eruption.

Its extent along the railway track is as nearly as possible a mile and a half and it forms the only rock traversed in the ascent of the mountain by the usual paths from "Shefford crossing." The second division comprises several rocks of different varieties both igneous and sedimentary folded together in a comparatively narrow band running along the western base of the mountain. It is about one-third of a mile in width on the railway, and so far as known does not appear on the more elevated portions of the mountain at all. The actual contact between these two divisions of the mountain has not yet been found.

The rock of the first or greater mass has a uniformly green color, showing gray grains on a freshly broken surface. Quartz veins are very abundant in it and joint planes and seams are often studded with small quartz crystals. Yellowish green patches, sometimes as much as a foot in diameter, [illegible] than the normal rock and stand out in relief on the weathered surface, owing to the presence of a green material of which they are [illegible] of which the mineral epidote appears to be a prominent constituent. The texture of the rock becomes much finer towards the outer edges and also towards the top of the mountain, where the cooling of the igneous mass would have taken place more rapidly and [illegible].

In thin sections examined by the aid of a microscope, the rock is found to have had its original characters much obscured by the excessive alteration of its component minerals, the primary constituents that remain being comparatively rare. In specimens from the summit the following minerals were distinguished: plagioclase feldspar, generally quite turbid from decomposition, though retaining its crystal outlines and occasionally plainly showing the distinctive multiple twinning; aggregates of chlorite, epidote and a light green or colorless hornblende (?) which are taken to represent primary pyroxene; an abundance of leucoxene, indicative of the existence of primary iron ore and indicating its titaniferous character; quartz, which is also apparently of secondary origin.

The arrangement of the feldspars in reference to aggregates of pyroxenic decomposition products, and to one another, is that characteristic of the structure of diabase, to which the composition indicated above also allies the rock. It is therefore an altered diabase closely resembling that known to occur at Owl's Head,* sixteen miles to the southward.

But it has been said that the rock is coarser in the central portions, while other variations also appear in it on more detailed examination. In these coarser parts such as are seen for the first one-third or half of the way up the mountain on the south side, the original structure was more granular than that of a diabase. The mineral olivine also appears, either enclosed in or associated with larger masses of fibrous hornblende, while the other mineral constituents are essentially the same as in the preceding specimens. While a rock of this composition and structure would be a dioryte, yet as the hornblende, from its fibrous character, irregular outlines and the probable presence of a little pyroxene in one slide, is likely in a large measure uralitic, it would have been originally a gabbro. It is accordingly best classed as a gabbro-dioryte , in the sense in which the term was used by Prof. G. H. Williams† in connection with an apparently similar phase of the Baltimore gabbros to indicate not only the composition and structure of the rock, but also its origin.

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*"Notes on the Microscopic Structure of Some Rocks of the Quebec Group," by Dr. F. D. Adams, *Rep. Geol. Survey of Canada*, 1880-1-2-3, p. 13 A.

†*Bulletin, U. S. Geol. Survey*, No. 28, p. 17, et aliter. The term is similarly used by F. D. Chester, "Gabbro and Associated Rocks of Delaware," *Bulletin U. S. Geol. Sur.* No. 58, pp. 15-19.

This rock cannot be sharply separated from the diabase just described, but passes into it gradually, many intermediate types being found. The two rocks are thus apparently differentiation products of a single magma and any line of separation between them could only be arbitrarily drawn.

The rocks of the smaller division on the western side of the mountain consist, as has been said, of a succession of sedimentary and [illegible] igneous rocks. The following horizontal section, [illegible] approximate measurements along the railway between Mellen and Eastman, will help to show the relative position and extent of the two main divisions as well as [illegible] of the smaller part. The direction of the [illegible] Mellen.

[illegible] near Mellen.

[illegible] mountain [illegible] feet.

[illegible] feet

[illegible] feet

enlargement of grains in crystallographic forms. The original grans being comparatively fresh in appearance and without any coating or iron the clastic nature of the rock is not easy to discern in all parts, especially as it is very compact, and hence the secondary silica is in relatively small amounts. Small fragments of a colorless mica are to be seen also, which are unlike any of the micas found in the accompanying igneous rocks. On the whole it is a rock that differs from the greywacke in conditions of deposition rather than in the character of the original fragmental material, and is probably only a phase of it.[§]

The serpentine is at this place darker in color than is usual in the eastern townships, presumably from the greater amounts of chromic iron which it contains. In the thin sections that have been examined, the alteration of the primary minerals has been so nearly complete that the entire field except for grains of iron ore, consists either of dull polarizing serpentine or of the allied secondary form, probably bastite, which has a fibrous structure with the extinction parallel to the fibres, and polarizes in rather brilliant colors. It agrees in all essential respects with the serpentine of Melbourne, which has been described by Dr. F. D. Adams,* and of which mass it is practically a continuous part.

Associated with the serpentnes are ophicalcytes and talc schists into which they appear to pass by rather sharp transitions.

The ophicalcytes are mottled, light and dark green rock and are often quite schistose. In the thin section as well as in the hand specimen, the only essential constitutens are seen to be serpentine and calcite. The former in some places is in parallel bands separated by calcite, in others it forms an irregular network having the interstices filled with calcite. or it occupies irregular areas in a groundwork of calcite. The calcite is well crystallized and is free from specks of graphite or other dark colored inclusions. But it is often penetrated by small strings or needles or a feebly polarizing mineral also thought to be serpentine. The boundaries between the two minerals are very irregular. A few grains of chromic (?) iron form the only other constituent of the rock.

[§] Logan, loc. cit.

*Op. cit. p. 19A..

The talc schists of slate are soft, greenish gray in color, and have the distinctive close or greasy feel. They are often finely laminated with a distinct cleaverage. In ordinary light the thin section appears colorless except for the presence of small grans of iron or leucoxene, which are somewhat evenly distributed throughout the field. Between crossed nicols the colorless mineral polarizes faintly in tints of gray. No crystal outlines are surely distinguishable in it.

An earlier origin is assumed for the western than for the much larger eastern division of Orford mountain from a consideration of the following facts, most of which have been already stated.

The serpentine and other metamorphic rocks are in a more advanced stage of alteration than the diabase, and are intricately associated with sedimentary rocks of Cambrian age and may be even older than these. The diabase and gabbro-dioryte mass, which, as has been said, forms the higher and greater portion of the mountain, contains little, if any, serpentine and clearly cuts strata recently determined on fossil evidence* to be of Cambro-Silurian age. Also, the serpentines, which with their associates occur very frequently along the southeastern side of the Sutton mountain anticlinal similarly associated with clastic rocks, without the presence of diabase at all, are here in a few instances cut by dykes, while no dykes have been found in the diabase. These dykes are too far altered to make it possible to determin their precise original characters. In the case of three near Orford pond the minerals augite, or secondary hornblende, are prominent constituents along with larger amounts of epidote, commonly in the form of zoisite, and in one case with a little quartz. They are not very different from the extremely fine, "aphanitic," form of the diabase as seen near its contact with the slates about Miletta and hence very probably belong to that mass.

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*Dr. R. W. Ells, *An. Rep. Geol. Survey of Canada*, Part J., p. 38; Dr. H. M. Ami, "Preliminary Lists of Organic Remains," Appendix to the above, Part J., p. 133. Dr. Ells also points out that Serpentine rarely if ever occurs in masses intrusive through strata of Cambro-Silurian age, op. cit. p. 80.

Accordingly, from the evidence thus far availa ological history of mount Orford would be briefly t

1. The parent rock of the serpentine was eith t in extensive sheets amongst the old stratified roc , or w extruded as a surface flow and these subsequently deposit upon them.

2. These rocks then became very intricately folded together, and were much worn down by long denudation.

3. An eruption of diabasic material took place along the eastern edge of the serpentine, which gave rise to the present mass of the mountain as well as to whatever part of it has been since removed by denudation. It is probably to this period, too, that the extrusion of the mountains along lake Memphramagog, Owl's H Elephantis, Hog's Back, belong, in which "serpentine very rarely, if ever, occurs.*

ON SOME NEWLY DIS NEPH-ELINE SYENYTE A.

By Willet G. Mill on

In a recent paper Dr. F occurrence of a large area cks on the northeast coast of lake Superior, western Ontario.† During the summers of 1897 and 1898 the writer was engaged in tracing out some belts of these rocks in eastern Ontario and showed that they cover a large area in this part of the province.‡ Prior to 1897 nepheline syenyte was known to occur in only one outcrop in the province.§ Late in 1896, however, corundum was found in this part of the province and as the deposit of this mineral appeared to be of economic value, the writer was engaged to make an examination of it and to search for other deposits in the district.

On examining the rocks in which the corundum occurred, it was found that they were generally either nepheline syenyte or of some other variety of syenyte. Outcrops of these rocks were traced along one belt about seventy-five miles in length and along two other belts of less length. In some parts of these belts the rock in which the corundum occurred was found to be not the alkali-bearing varieties, the various syenytes, but the alkaline-earth rocks, anorthosytes.¶

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*Dr. R. W. Ells, op. cit. p. 80 J.

†Journal of Geology, May-June, 1900.

‡Reports, Bureau of Mines, Toronto, 1897-8.

§Am. Jr. Science, July, 1894.

From the character of these belts, at their extremities, it was believed that they could be traced still farther in an east and west direction.

Late in the autumn of 1899 the writer, while spending a few hours in the vicinity of the city of Hull, Quebec, discovered a well-rounded boulder containing grains of nepheline, which confirmed his belief that the belt of these rocks continued eastward from the province of Ontario across the Ottawa river into the adjoining province, and early in the present year he discovered nepheline syenyte in place about twenty miles east of the Ottawa river.

The rock found here was composed essentially of a white feldspar and nepheline in grains, some of which had a diameter of two inches, together with a little black mica. The rock is similar in character to much of that found in the corundum belt of eastern Ontario. Time did not permit of an attempt being made to trace out a belt of these rocks to the east of the Ottawa river, but from what was seen of the outcrops and from his knowledge of the field relations of these rocks in Ontario, the writer believes a belt of considerable length exists in this part of Quebec.

A thin section was made of a fragment of the Hull bounlder. Under the microscope the rock is seen to be composed of orthoclase. microperthite acidic plagioclase and nepheline, together with considerable dark grown mica. The section also showed several grains of calcite with somewhat rounded outlines. This occurrence of calcite in the section is an interesting feature of the rock, as it was also found to be present in the first specimens of the rock examined in Ontario by Dr. F. D. Adams, and has since been found in specimens of the rock from a number of other localities in the province. The fact has been referred to that this carbonate has the appearance of being an original constituent.*

There are several somewhat puzzling features in connection with this whole series of nepheline-bearing rocks. Among these are the great variation in size of grain and mineralogical composition in parts of the same masses, the presence of grains of calcite and scapolite, both of which have the appearance of being original constituents, and the occurrence in some of the masses of crystals of apatite some inches in length. It will be seen that in these features these rocks resemble to some extent certain of the Canadian apatite deposits. In these deposits water, in a highly heated state, has been considered to be the chief agent concerned in the deposition. It would seem then that water may have played a more inportant part in the deposition of the nepheline-bearing series than in the case of other so-called igneous rocks.

¶Am. Geol., November 1899, with map.

*Am. Jr. Science, July, 1894, p. 14.

A short time ago the writer made a hurried trip into another part of Quebec about 140 miles to the northwest of the locality to which reference has just been made, and was somewhat surprised to find an outcrop of nepheline syenyte and related rocks there. This outcrop is situated on the Kippewa river about twenty miles to the northeast of the southern end of lake Temiscaming, which forms the head waters of the Ottawa river. The breadth of this outcrop, so far as exposed above the surface of the water and drift material, is about 400 yards. The rock in the outcrop shows a well-developed schistose structure and a considerable variety of mineralogical composition, in a direction at right angles to the strike, as do many of the outcrops in Ontario. Much of the material has the composition of mica or hornblende syenyte, while some of it is more basic, holding a high percentage of hornblende. A not inconsiderable portion of the rock has the composition of nepheline syenyte. The nepheline is in grains of different size up to pieces three inches in diameter. Some of the hornblende associated with the nepheline and feldspar is in the form of masses whose diameter is four inches.

It was observed, in tracing out the nepheline rocks in Ontario, that they were nearly always associated with crystalline limestone. No attempt was made, however, to explain this association.

The first outcrop found in Quebec during the past season is also associated with crystalline limestone.

In the district lying immediately to the west and southwest of the Kippewa outcrop which has been geologically surveyed by Dr. A. E. Barlow and which embraces a territory of over 4000 square miles, three quarters of which is Laurentian, crystalline limestone was found in only a few small areas.[*] Since this rock was of so rare occurrence in the district which has been mapped, it was not expected that it would be found in abundance just outside this area. On discovering the outcrop of nepheline rock, however, the writer stated to those accompanying him that it was very likely they would find crystalline limestone not far off. On proceeding up the river a short distance, the limestone was found in place.

From the discovery of outcrops of nepheline syenyte over such an extensive territory in Ontario and Quebec, it would appear that no Laurentian area of any great size in central Canada, which contains much crystalline limestone or in other words which belongs to the Grenville series, is without the presence of nepheline syenyte and related rocks. This is of economic importance, in addition to any scientific interest it may have, as very promising deposits of corundum have been found at different points, in certain facies of these rocks, some of which are now being worked on a comparatively large scale.

The reason why these rocks have not been discovered in many places in this part of Canada in earlier years are no doubt the non-familiarity of many observers with the appearance of nepheline in the field, owing to its comparative rareness in most countries, and its resemblance under some conditions to other light colored minerals. Two instances can be cited in which rocks containing nepheline were examined megascopically years ago and in which the mineral wsa mistaken for quartz. One of these is the case of the syenyte of Montreal mountain, in which it is said the nepheline was mistaken for quartz for years. The other is the case of centain outcrops along the York (Shawashkong) river in Hastings county, which were examined in 1853 by the late Alex. Murray, and described by him in his reports as "hornblende rock" and mica slates."[†] These outcrops while they are more or less schistose in character, still contain the nepheline in distinct grains, some of which are of considerable size.

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[*] *Report Geol. Surv.* Can. I, p. 89, 1897.
[†] *Geol. Surv.* Can. 1843-6, Map No. 17.

Boulders of nepheline rocks were found many years ago in the region north of lake Superior.[*] Dr. A. C. Lawson discovered rocks containing the mineral in the Rainy River district, towards the western boundary of the province, some 800 miles west of the eastern outcrops.[†] It would thus seem that no really large area of the Archæan in this part of Canada is without the presence of the nepheline-bearing series. These outcrops whether they be considered of Laurentian or Huronian age, may be all looked on as having come originally from the same magma. Many of the districts, however, in which these high alkali-holding rocks occur cannot be said to be characterized by the presence of these alone. Large areas of rocks holding a high percentage of alkaline earth metals are of just as common occurrence. This is especially true of those areas in the extreme eastern and western parts of Ontario and the western part of Quebec. At localities on either side of the boundary between these two provinces, anorthosytes, including among others the well known Morin area, occur in large masses, and from the fact that corundum occurs in some of these as well as in the nepheline-holding rocks, there seems to be little doubt that these rocks whose bases, in addition to alumina, are essentially the alkalis, sodium and potassium, and those whose basic constituent in place of the alkalis is chiefly calcium, are the products of one magma.

PENEPLAINS OF THE OZARK HIGHLAND.

By Oscar H. Hershey, Bragdon, Calif.

The Ozark highland comprises all of the mountain country of Arkansas, the eastern portion of Indian Territory, and most of the hill-country of Missouri south of the Missouri river. On the north and west it is bounded by the long eastward slope of the "great plains" and the Upper Mississippi region; on the east by the Illinois depression and the Mississippi embayment country, and on the south the sloping plains of Cretaceous and Tertiary strata stretch from its borders to the gulf of Mexico. It is separated into two somewhat distinct uplifts, by the long, narrow Arkansas basin, which is a structural and physiographic as well as a topographic depression.

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[*] Geol. Can. 1868, p. 480, and Reports for 1846-7.

Bull. Univ. Cal., 1896.

South of the Arkansas valley, the country is characterized by the long, narrow east-west ranges of the Ouachita mountains, surmounting a dome-shaped "uplift" or elevated area of the deformed Tertiary peneplain. These ridges are truly mountains, and bear a marked resemblance, both in stratigraphy and structure, to portions of the Appalachian mountain system. They correspond to the Blue mountains and similar ridges in Pennslyvania, east of the main Alleghany range.

The synclinal trough of the Arkansas valley has no representative in the Appalachian region, but topographically the valley of east Tennessee is its counterpart. The former separates the true mountain portion of the Ozark highland from the northern or plateau division. This latter is what is commonly known as the "Ozark uplift," and many would restrict the name Ozark to it. The plateau is a great dome-shaped, elevated tract of the deformed Tertiary peneplain which attains a maximum altitude of about 1,750 feet A. T. in northwestern Arkansas near Fayetteville, and slopes thence gently to the north and east, and more steeply toward the west and south. It is surmounted, along a line 20 to 30 miles north of the Arkansas river, by an east-west range of mountains commonly referred to collectively as the Boston mountain. This corresponds to the Cumberland and main Alleghany ridges of the Appalachians, and the broad plateau north of it is the counterpart of the Alleghany plateau.

This close resemblance of the physicial features of the Ozark highland and the Appalachian mountain region has frequently been commented on. It is also known that the history of the physiographic development of the two areas has been essentially alike in character, as all orographic and epeirogenic disturbances of the one have affected the other also. However, the geomorphology of the Ozark province is not so well known as that of the Appalachians, and a generalization of its physiographic features may be of interest, if not also instructive, to students of American geology.

The Cretaceous peneplain.—This, as Mr. L. S. Griswold has identified it, emerges from beneath the Cretaceous strata in extreme southwestern Arkansas and southeastern Indian Territory, and rises at quite a perceptible rate toward the north. The plain-like character is soon lost, and the peneplain is represented by long, narrow ridges whose remarkably even crests constitute the remnants of the ancient plain of denudation. Still farther north, in Polk and neighboring counties of Arkansas, and the adjacent portion of Indian Territory, the ridges with even crest-line have disappeared, but the peneplain seems represented in a general way, by the long east-west mountains rising 1,200 to 1,500 feet above the general level of the country, and separated by basins five to twenty miles wide. Of these ridges, some of the most prominent are the Push, Rich, Poteau, Cavanal, Sugar Loaf and the Magazine mountains. There are many low passes through them, and they show a tendency to isolation more than the Appalachian ridges. Indeed, several stand alone, in monadnock-like masses, on the Tertiary peneplain. Only in a few instances are their summits clearly truncated by a plane of erosion base-level. Several of the highest have flats of sufficient extent to afford room for farms on the mountain-tops, notably the Rich and the Magazine mountains. However, there is such a general similarity in hight between contiguous portions of the mountain system (and neighboring peaks) as to leave little doubt that the Cretaceous peneplain is approximtely represented by the summits of the Ouachita mountains at an average elevation between 2,000 and 2,500 feet, reaching a maximum of about 2,750 feet on Rich mountain on the line between Arkansas and Indian Territory, and sloping thence very gently to the west and north, and more steeply to the east and south.

Between Cavanal, Sugar Loaf and the Magazine mountains on the south of the Arkansas valley, and the Boston mountains on the north of that broad basin, the Cretaceous peneplain has been completely destroyed over a width of probably fifty miles, and extending east and west completely across the Ozark highland. But it is undoubtedly again represented in the Boston mountain at an everage elevation of 2,000 feet, reaching a maximum of 2,257 feet near Winslow on the S. L. & S. F. R. R. Unlike the narrow ridges south of the Arkansas river, the Boston mountain is a dissected plateau, ten to fifteen miles wide, trending east to west, bowed slightly along a central line, but otherwise remarkably even in surface. The erosion of valleys 500 to 1,000 feet in depth has pretty thoroughly cut up this plateau into flat-topped ridges, although there are undissected tracts of 300 or 400 acres as level as any plain. The origin of these flats is difficult of explanation except on the theory that they are remnants of an ancient baselevel of erosion, a peneplain. Nearly all the ridges reach this peneplain level.

The Boston mountain is monadnocked upon the Tertiary peneplain to the extent of about 500 feet vertical. Hence, the dissected peneplain to its summit is an oldr one. From the general correspondence in hight between the Ouachita mountains and the Boston mountain, it appears evident that the same peneplain may be represented in both. Hence, I feel safe in identifying the Cretaceous peneplain north of the Arkansas river, at a maximum altitude of about 2,250 feet near Winslow and 500 feet above the main Tertiary peneplain.

Northward from the Boston mountain, the Cretaceous peneplain is represented by isolated outliers of the main plateau—flat-topped peaks, sometimes elongated into ridges—in other words, by a series of monadnocks standing on the Tertiary peneplain. These are mainly of Coal Measure shales and sandstones and some might consider them as due to structural rather than physiographic conditions. However, I am confident that many of them (especially those whose summits are truncated) are remnants of the Cretaceous peneplain, so well represented on the Boston mountain. This gradually descends toward the north and approaches the main Tertiary peneplain; near Hindsville, in Madison county, Ark., there is an interval of only a few hundred feet between them, and near Eureka Springs, several monadnocks forming small groups widely separated from each other and far distant from the main system near Boston mountain, seem to indicate that here the Cretaceous peneplain has descended to within 100 feet of the lower baselevel.

Over the Ozark plateau region of southern Missouri, it is doubtful if any hill can be positively identified as a remnant of the Cretaceous peneplain. There are a few low monadnocks in Stone and Barry counties, which seem to belong to the same system as those of north Arkansas. One in particular near Scholten, in the latter county, is a narrow, flat-topped ridge rising about fifty feet above the surrounding plain. Coal Measure sandstone and Burlington limestone are so combined in its structure as to make its truncated summit difficult of explanation under any other than baseleveling conditions. I am inclined to believe this is a remnant of the Cretaceous peneplain, here only fifty feet above the Tertiary. Northward from here, along the so-called "crest" of the Ozarks they may be completely merged into one.

The main Tertiary peneplain.—Between the narrow Ouachita mountain ridges of south-central and southwestern Arkansas, there are broad basins which, like the inter-montane valleys of Pennsylvania, represent the Tertiary peneplain. In the vicinity of Mena, in Polk Co., Ark., the surface is gently undulating, the streams not having cut much below the originally very flat peneplain. It is here elevated about 1,300 feet above sea-level, but slopes gently in all directions, particularly toward the east and south. Southward from Mena, there are tracts of many square miles, where the surface is a remarkably level plain. But if we go northward from Mena, toward the Arkansas river at Fort Smith, after passing Rich mountain through Eaglegap, we find the floors of the intermontane basins quite thorougly dissected by narrow valleys separating still narrower ridges. These ridges are long and straight, remarkable for their even crests, and for their equal hights. In other words, the summit-plane of these ridges forms as perfect a dissected peneplain as can anywhere be found on the American continent. This imaginary plain is absolutely indifferent to the stratigraphy and structure. That it represents a base-level of erosion common to the entire Ouachita region is demonstrated by the fact that its slope in each basin is uniform in direction and degree with that of contiguous basins; that is, were the Ouachita mountains removed, and the valleys filled to the level of the long, even-crested ridges of the basins, the whole country would be perfectly even plain, rising toward a central point near Mena to form a dome-shaped elevation of the land—the Ouachita uplift. This is the main Tertiary peneplain of southern Arkansas and Indian Territory. On it stand the Ouachita peaks and ridges like monadnocks and catoctins, and beneath its plane are trenched narrow basins and canyon valleys of systems to be described later.

This Tertiary peneplain emerges from among the mountains to form the very even plain of the Arkansas valley where for a width of fifty miles or more it is not interrupted by any monadnocks. Standing on a slight elevation and looking across the Arkansas valley, the surface appears to be a remarkably even plain, sloping very gently from the prominent mountains on the south toward the Arkansas river, quite perceptibly eastward or down the valley in Indian Territory west of Fort Smith, and very decidedly from the Boston mountain to the river. In short, the deformation of the plain can be very clearly seen from any point of vantage. Along the axis of the trough flows the Arkansas river and in its vicinity at Fort Smith and Van Buren the Tertiary peneplain has no greater altitude than 600 feet above the sea.

I have said the Arkansas valley appears like a very even plain, but in reality it is not. The original plain has been pretty thoroughly dissected, and remains only in narrow ridges. South of the river, there are the long, straight, even-crested east-west ridges as in the inter-montane basins. Many of these ridges are 200 to 300 feet in hight and are locally known as mountains. In places they are separated by considerable basins, and the streams cut through them in narrow gorges like the water-gaps of Pennsylvania. Indeed, the topography is that of the eastern Pennsylvania and northern New Jersey mountain country on a smaller scale.

North of the Arkansas river, the ridges which form the dissected Tertiary peneplain are less regular in crest-line and trend prevailingly in a north-south direction. Now an extremely curious feature of Ozark highland structure comes to light. Generally the slopes of the peneplains in the Ozark region are at a very low angle. But here on the southern slope of the Boston mountain the Tertiary peneplain descends steeply from an altitude of about 1,700 feet A. T. near Winslow to 600 feet A. T. near Van Buren, a distance in an airline of little more than twenty miles. This gives the peneplain's remnant-ridges on the north of the Arkansas river a very decided slope lengthwise or along their axes. In fact, they soon rise up to form the foot-hills of the Boston mountain, and just where the dissected peneplain leaves off and the mountain spurs begin to be monadnocked on it, is not everywhere easy of determination.

Within the Boston mountain the Tertiary base-level is hardly recognizable. The valleys on the southern slope are cut through the interval between the Cretaceous and Tertiary base-levels and far below the latter. Those north of the divide are not so deep and hardly reach the level of the Tertiary peneplain. But in emerging from the mountain on the north, the newer peneplain is soon encountered, in one of its most typical and unmodified forms, at an average altitude of about 1,700 feet A. T. Standing on a spur of the Boston mountain, one may look northward for many miles over a country distinctly lower and apparently a regular plain upon which rise the outliers of the Coal Measure strata. The plain is pretty thoroughly dissected by narrow basins and still narrower canyon valleys. In places there are long, narrow, even crested ridges as in south Arkansas, but usually the drainage systems are of a perfect dendritic type, and the ridges branch and re-branch like the limbs of a tree. Near the White river, the whole country is cut up into a complex of very narrow ridges and gorge-like, V-shaped valleys, some of which are so deep that the intervening remnants of the strata are called mountains; notably the Eureka mountains in Arkansas, and the Carney mountains in Missouri. The same topography prevails along the Osage river and, indeed, belts of such extremely rough country follow all the main streams in the Ozark plateau region.

That the general upland surface from the northern base of the Boston mountain to the Missouri river represents one and the same dissected peneplain needs no elaborate demonstration. Where the plateau is trenched by deep valleys and even such broad basins as that along the White river in Missouri, the "mountains" on either hand correspond in hight. The most broken portion of the Ozark plateau, when looked at from a distance, appears like a plain of remarkable evenness. Along the main divides, such as that followed by the S. L. & S. F. R. R. from Lebanon to the Boston mountain, erosion has not been active, and the streams have not cut deep valleys into the surface. Here the plain-like character of the country in the Tertiary era has not been destroyed. The land is generally rolling, and the "crest" gently ascends and descends, but it is evident that it is the same plain which is being followed from end to end.

This Tertiary peneplain descends very slowly from its maximum of about 1,700 feet in northwestern Arkansas, to about 1,500 feet on the Pea ridge, where it is crossed by the Missouri line, and thence to 1,300 feet near Springfield and Lebanon. A local uplift of no great extent seems to elevate it to about 1.700 feet at Cedar gap in Missouri. The White River valley in Missouri occupies a kind of depression in the surface of the peneplain. The same Tertiary base-level is represented by the main ridges of the undulating plain about Joplin in extreme southwest Missouri, at about 1,000 feet A. T. It is the same peneplain which forms the general upland surface of eastern Kansas. Thence southward through Indian Territory it may be traced around the Boston mountain to the Tertiary peneplain in the Arkansas valley, thus escaping the complication of the curious monocline on the southern slope of the Boston range.

North of the so-called "crest" of the Ozarks in southern Missonri, the peneplain continues to descend gradually, and has no greater elevation than about 900 feet at Boonville and Jefferson City on the Missouri river. The highest hills in the vicinity of both towns represent it. It is much dissected all along the Missouri river, but there are enough remnants left to demonstrate that it is present on both sides of the comparatively narrow valley.

The Lafayette base-level.—In that portion of the Ozark highland which is south of the Arkansas river, a large part of the surface has been reduced by erosion below the main Tertiary peneplain to a later and relatively lower base-level. This Pliocene or late Tertiary cycle of erosion resulted in the formation of broad, shallow basin valleys whose floors were once quite flat, being composed of the broad alluvial plains of the streams of that period. They are now dissected by the canyon valleys of later age, and may easily escape detection except upon close observation. In approaching the Arkansas river, these basin valleys become quite pronounced, spreading out into undulating plains three to five or more miles in width, and separated by the ridges which constitute the remnants of the main Tertiary peneplain. One of these small peneplains, extending westward from Fort Smith, is of particular interest. for its surface is sheeted with the gravelly alluvium of the Lafayette formation. This fixes the age of the completion of the basin valleys as Lafayette, and the plane of their floor throughout the Ozark region may be designated the Lafayette base-level. In the vicinity of Fort Smith it is about 100 feet lower than the main Tertiary peneplain, and over all of south-central Arkansas and east-central Indian Territory it maintains a level 75 to 100 feet below the earlier base-level.

Between the Arkansas river and the Boston mountain, there are, among the hills, certain depressed areas which seem to represent the Lafayette base-level at a level about seventy-five feet below the main Tertiary peneplain as the latter is fixed by the general upland surface. In this region the physiographic features are obscured because of the abnormal southward slope of the country which has especially favored post-Lafayette erosion. But in northern Arkansas, on the Ozark plateau, we find the basin valleys well defined. All the principal streams flow in valleys which are duplex in character, being composed of a broad upper trough, beneath the floor of which is trenched a narrow canyon valley. Along that portion of the White river which passes through Missouri there is a basin three to five miles in width, trenched through the Lower Carboniferous cherty limestones and well down into the dolomytes of the Ozark series. Its floor is everywhere dissected by the canyon valleys of Ozarkian age. but the main hill-tops seem to represent a base-level of erosion at a level between 200 and 300 feet beneath the main Tertiary peneplain. Passing up the tributary valleys, this base-level is represented by persistent rock-terraces along the valley sides, some of which spread out into benches of sufficient width to be occupied by farms. They are especially noticeable on the War Eagle fork of White river in Arkansas, and the James river and its tributaries in Missouri. In this region, the rock-terrace always occurs at about the same level relative to the main Tertiary peneplain, namely, nearly 300 feet below it.

In the extremely broken and even truly mountainous country of the King's river hydrographic basin in Arkansas, one may stand on one of the ridges of the Eureka mountains and look far to the eastward across a vast complex of hills. Three base-levels are distinctly noticeable. The summits of many of the ridges form the dissected floors of basin valleys often several miles in width, and which occupy three-fourths of the entire surface. This is the Lafayette base-level. Several hundred feet higher, the main upland ridges represent the Tertiary peneplain. Looking across their summits the very hilly country in the far distance apparently merges into a plain. The sky-line is even with the exception that a few monadnocks rise above the peneplain. Some of them are cone-shaped, but several are elongated into ridges whose crests are even and summits flat, suggesting the Cretaceous base-level. In all the Ozark region, this is one of the most instructive to the student of physiography.

The existence of the basin valleys, rock-terraces, and depressed areas among the hills of the entire Ozark highland country is a fact which may be verified by anyone who doubts it. It is also a fact that they have their level irrespective of the rocky structure, and that the frequent concurrence of the floor of the basins with the top of centain formations is merely fortuitous. These basin-floors and rock-terraces often bevel the edges of the strata, and they may be observed to pass from one formation to another without deformation. Hence, there is every reason to consider them to represent a base-level of erosion distinct from and considerably later than the main Tertiary peneplain. In many places from the Arkansas to the Missouri river, this base-level is the site of remnants of an ancient river alluvium containing a peculiar brown gravel which is known to be of Lafayette age. The presence of this river-gravel is corroborative of the Lafayette age of the base-level as drawn from purely geomomphologic evidence.

The vicinity of the White river appears to be the region in which there is the greatest interval between the main Tertiary and the Lafayette base-levels, here reaching a probable maximum of 300 feet northward from the "crest of the Ozarks;" in the Osage basin and along the Missouri river, the difference in level is only about seventy-five feet. In this region the duplex character of the valleys is not so prominent, but is still noticeable. Near Bunceton, in Cooper county, Lafayette remnants occur about two-thirds of the distance from the valley bottoms to the hill-tops. At this level there are frequently distinguishable "shoulders" or benches on the hill-slopes, and sometimes there occur in the valleys ridges whose truncated summits lie no higher than the Lafayette base-level. When one's attention is once called to it, it is not difficult to recognize the "trough within a trough" character of these valleys.

In approaching the Osage river, the country becomes extremely broken. The remnants of the Tertiary peneplain become isolated into widely separated elongated ridges and small flat-topped peaks, none of which approach very closely to the river. The steep, rocky ridges which bound the narrow and very crooked canyon valley represent, in a very imperfect manner, the Lafayette base-level, here also about seventy-five feet below the main Tertiary or "Tennesseean" base-level. That the tops of these "river-hills" actually represent a plane of stream erosion is indicated by a curious depressed area or valley among the hills about four and one-half miles north of Lime creek. Here the canyon valley of the Osage makes a great bend to the southward and encloses a peninsula-shaped tract of upland. A considerable portion of one of the higher ridges (a remnant of the Tertiary peneplain) is cut off by a distinct valley or depression in the hills, having a width of about one mile, a depth of seventy-five feet, and steep slopes like an ordinary river valley, but whose bottom is dissected by transverse ravines just as all the remainder of the upland is. This abandoned valley connects the basin valley above the great bend with that portion below it, and during the Lafayette period undoubtedly was occupied by the Osage river. This valley, the hill-tops along the Osage, and the remnants of Lafayette stream-gravels in Cooper county, unite in fixing the Lafayette base-level of erosion in central Missouri at a level only seventy-five feet below the main Tertiary peneplain, and all that portion of the valleys of greater depth than this is essentially Ozarkian in age.

In southwestern Missouri, in Jasper and neighboring counties, the declivity of the streams is not great, and the valleys are broad and without the canyon form except very locally The Lafayette base-level would be difficult to detect here, were it not that a few remnants of the Lafayette stream-gravels have been found, notably near Duneweg, about six miles due east of Joplin. They indicate that to Pliocene erosion may be charged the upper one-third of the valleys, thus placing the Lafayette base-level at fifty to seventy-five feet beneath the main Tertiary peneplain so well represented by the general upland surface. There are rock-terraces along Shoal creek, south of Joplin, but they seem of later age than the Lafayette. A somewhat similar rock-terrace along the Spring river in Cherokee county, Kansas, is doubtfully referred to the same category as the terraces of James river and Flat creek in Stone and Barry counties, Missouri, known to be of Layfayette age.

In short, that after the completion of the main Tertiary (presumably Tennesseean) peneplain, there ensued another (and vastly shorter) cycle of Tertiary erosion, resulting in the formation of a type of valleys which have been designated "basin valleys," because they are broad and shallow and have gently sloping sides, of supposably Lafayette age in their completion, may be gathered from evidence scattered all over the Ozark highland region. This implies, beyond doubt, an elevation of the province in general of an epeirogenic character, but also to a slight extent orographic, as is indicated by the 250 to 300-foot depth of erosion in the White River basin, in place of the normal seventy-five to one hundred feet of nearly the whole remaining portion of the Ozark region. It is this differential character of the uplift which strengthens the evidence.

Before closing this subject, I desire to remark that the same or a like system of basin valleys trenched beneath the main Tertiary peneplain is a recognized feature of the geomorphology of northwestern Illinois and contiguous areas, and are known to me to exist in the inter-montane valleys of Pennsylvania and New Jersey. May they not be recognized in the southern Appalachian province, whose physiographic history is otherwise so nearly like that of the Ozark province?

The Ozarkian valleys.—The narrow, crooked valleys trenched beneath the Lafayette base-level include the erosion of the Glacial and post-Glacial subdivisions of the Quaternary era, but the major portion of their excavation seems to have been accomplished during that long, early epoch of the Pleistocene period marked by an abnormal elevation of perhaps the whole of the North American continent, and which has come to be known as the Ozarkian epoch or sub-period; hence, for convenience in discussion, I shall refer to the lower troughs of the Ozark highland as the Ozarkian valleys. The canyon-like form is a characteristic of them which seems to be persistent throughout the Mississippi basin, particularly on the limestone areas. It reaches its most typical development in south-central Missouri, along such streams as the Osage and Gasconade rivers and their tributaries. The canyon valleys of this region have been so often described that I will merely mention the facts that they are steep-sided troughs winding about in the bottoms of the basin valleys, have frequently a mural precipice on one side and a steep slope, strewn with river-gravel, on the other, and are rarely more than several times as wide as the streams flowing into them. The canyon valley of the lower Osage averages one-half mile in width and about 150 feet in depth. Nowhere else in the Ozark highland are the Ozarkian valleys of much greater depth than the Pliocene basin valleys. Throughout the northern slope of the Ozark plateau they vary between 100 and 200 feet in depth, while the upper troughs are but half as deep. Yet the latter are several times as wide, and from their character indicate a much longer period of erosion.

On the so-called "southern slope of the Ozarks" in Missouri (including the White River basin), the Ozarkian valleys are essentially of the same character as that of the Osage, having the meandering courses and the mural percipices. The canyon valley of White river in Missouri is scarcely 1,000 feet in width and 150 to 200 feet in depth. Winding about in a Pliocene basin valley from three to five miles in width and nearly 300 feet in depth, the contrast between them is extremely marked and significant. Nearly the whole of the James River valley and tributaries, such as Flat Creek valley, from the main Tertiary peneplain down, has the canyon form and winding course, but only the lower sixty to one hundred feet is Ozarkian in age, the 200 to 300 feet above the rock-terraces being of Pliocene age. In short, in this central portion of the Ozark plateau, while the Ozarkian valleys still occur in as characteristic a form and as great a development as in the Osage country, they are quite subordinate to the valleys above the Lafayette base-level. I wish to have this fact distinctly understood so that there may be no confusion as to the origin of the term, "Ozarkian." It was derived through the fact that the erosion products of the long epoch between the Lafayette and the earliest Glacial epoch are so well represented in the river valleys of the Ozark plateau, but even here not all the valleys belong to it. In the Ozark highland south of the Missouri line, the Ozarkian valleys are comparatively insignificant, and the name would be inappropriate, were it not for their fine development in south Missouri on the northern half of the Ozark plateau.

On the War Eagle fork and the main fork of White river in Arkansas, the Ozarkian valleys are small troughs, twenty to thirty or even fifty feet in depth and several times the width of the contained streams, trenched beneath the flat rock-floor of much larger valleys. In he Boston mountain region, no valleys can be pointed out as distinctively Ozarkian, although the bottoms of the deeper valleys on the southern slope must reach much below the Lafayette base-level. These valleys began to form at the close of the Cretaceous period, and have continued uninterrupted to the present day. They had not been cut down to a base-level before a new uplift occurred and the base-level of erosion was again lowered. But no sooner do we go out of the mountain region on the south, where the Lafayette base-level becomes apparent well up in the hills, when we find that here the Ozarkian valleys are quite large and deep, being comparable with those in Missouri. As the whole country sinks rapidly to the Arkansas river, these valleys become shallower, spread out to a considerable width, and finally pass into the southern Arkansas type of Ozarkian valleys, of which the lower trough of the Arkansas river is a good example.

Near Van Buren and Fort Smith, Ark., the highest hills near the river (about 200 feet above it) are remnants of the main Tertiary peneplain. Midway between it and the river-level, are the depressed areas, sometimes in terrace form and sometimes passing inland as gently rolling plains of solid rock sheeted with the Lafayette gravels, silt and clay (even "orange sand"). Below this level, the Arkansas has excavated a valley probably three to five miles in width and 100 feet in depth. This corresponds to the Ozarkian valleys of south Missouri.

On the eroded plain country south of the Arkansas river, and in the broad inter-montane basins to as far south as the Rich mountain, the streams have cut comparatively narrow valleys beneath the Lafayette base-level. These may average fifty to one hundred feet in depth and are usually of sufficient width to afford room for long, narrow farms on their flat bottoms. Their sides are steep, but mural precipices are rare. They are canyon valleys in distinction from the basin valleys above, but have the canyon form less typically than in south Missouri. In Polk county, which is on the divide between the Arkansas and Red river drainage systems and erosion is not active, the canyon valleys are hardly represented at all, the streams flowing in shallow depressions or "hollows" on the peneplain. Indeed, throughout the Ozark highland south of the Arkansas river post-Lafayette erosion has been insignificant in results attained, and one almost refuses to believe that the shallow post-Tertiary valleys of that region are the equivalents of the deep valleys of the Ozark plateau and the upper Mississippi regions.

The Modern valleys of central Arkansas.—Under this heading are to be discussed certain small canyons occurring along streams tributary to the Arkansas river in central Arkansas, and which belong to a system, it is beleved, not heretofore identified and defined in any other portion of the Mississippi hydrographic basin. That of the Little Cedar creek, northeast of Van Buren, was the most typical one observed, and a description of it may serve for all. The rock formation is a thin-bedded, calcareous shale of the Coal Measure series, dipping at a low angle but quite perceptibly toward the south. In this the creek has excavated quite a large Ozarkian valley, with steep sides and a flat rock-floor one-eighth to one-quarter mile in width. This rock-floor is very even and is sheeted with a few feet of silty alluvium. It bevels the edges of the outcropping shales, which dip down stream.

Now, the Little Cedar no longer flows over this old valley floor, but in a tiny canyon, mostly twenty to thirty feet in depth, but at places amounting to fifty feet, which it has excavated in the bottom of the Ozarkian valley. This canyon is scarcely anywhere wider than the stream which is itself contracted to a swift mountain brook, and its walls are mostly perpendicular precipices along which the rocky strata are finely exposed, showing that structure has had nothing to do with the existence of this canyon in the bottom of the vastly larger Ozarkian valley above. It has the appearance of extreme recency of inception. It is crossed by rock-ledges over which the stream cascades, and is obstructed by large blocks which have fallen from the walls. There is a freshness, a youthfulness about it which I have only observed heretofore in post-Glacial rock valleys in the Wisconsin drift area.

This recent canyon of probably Modern age (it is forming today) gives out before the Arkansas river is reached. It is a feature exclusively of the middle course of the Little Cedar (and similar creeks flowing down from the Boston mountain). The smooth valley floor above it could not have been formed while the stream had its present rapid rate of descent. This indicates a tilting of the valley toward the Arkansas river. This, with the presence of the canyon, postulates a very recent differential uplift of the Boston mountain region. It will be remembered that earlier in this discussion we found a remarkable monocline in the main Tertiary base-level between the Boston mountain and the Arkansas river. The Lafayette base-level partakes in this unusual deformation almost to the same extent as the Tennesseean. It was probably during the early part of the Quaternary era that this abnormal slope was mainly produced, but the testimony of the tiny rock-canyons of Modern age indicates that a movement of a similar nature has occurred in very recent times and may be in progress today. Certain peculiarities in the streams of southern Missouri and the fact that there has been a wholesale change in the places of emergence of the springs in times very, very recent have led me to believe in a pronounced uplift of the whole Ozark plateau in the Modern epoch (if it is not in progress today), and now these modern canyons of west-central [illegible] light to corroborate the idea, at least as applied [illegible] mountain region.

[illegible] generalizations on the history of the physiographic development of the Ozark highland, may be briefly summarized as follows:

1. The entire region was reduced by subaërial erosion to base-level, forming the Cretaceous peneplain.

2. A great dome-shaped uplift was instituted over the site of the southern two-thirds of the present Ozark highland. The amount of elevation was 1,200 to 1,500 feet in west-central Arkansas, 500 feet in the Boston mountain region, 100 feet along the Missouri-Arkansas line near Eureka Springs, and nothing from the "crest of the Ozarks" north. The long Tertiary cycle of erosion again base-leveled this region, forming the main Tertiary or "Tennesseean" peneplain, except that residuals were left in the Ouachita and Boston mountains.

3. An uplift, general throughout the Ozarks, of seventy-five to one hundred feet, increasing to 300 feet in the White River country, enabled a Pliocene cycle of erosion to excavate the broad basin valleys and reduce much of the country to a new base-level. The close of this cycle of erosion was contemporaneous with the end of deposition of the Lafayette formation in the Mississippi embayment region.

4. Another general uplift, insignificant in amount south of the Arkansas river, but increasing to a maximum of *at least* several hundred feet in southern Missouri, enabled the streams to excavate the canyon valleys of Ozarkian age.

5. An undoubted local uplift of the Boston mountains and contiguous areas in the Modern epoch. As most of the Ozark highland is far above a base-level, it may be presumed that the late Quaternary elevation has been quite general, but has occurred so recently, geologically speaking, that only in a few limited areas are its effects as yet noticeable.

Nov. 15, 1899.

CORRESPONDENCE.

TROOST'S SURVEY OF PHILADELPHIA. Apropos of Dr. Merrill's interesting communication in the December number of this journal I beg to call attention to the fact that, safely housed in the library of the Academy of Science of Philadelphia along with other bibliographical treasures, is a copy of Dr. Gerard Troost's Survey of the environs of Philadelphia. It is apparently a direct counterpart of the work noted by Dr. Merrill. It is somewhat remarkable that Lea or Conrad should have been unaware of the volume in question and that the Marcous should have been unable to record its occurrence. Recently a Philadelphia bookseller offered a copy for sale. In regard to the German title mentioned by the Marcous, it may refer to a compilation on the geology and mineralogy of North America issued in Hamburg about 1827, to which Dr. Troost among others contributed. As far as I know this publication contained no map.

S. Harbert Hamilton.

NEW YORK ACADEMY OF SCIENCES, SECTION OF GEOLOGY AND MINERALOGY, OCTOBER 15, 1900. The following notes on the results of the summer's work by members were presented:

MR. GILBERT VAN INGEN described the work of the party belonging to the Geological Survey of New Jersey, which, during the past two summers, has been engaged in tracing the outcrops of the palaeozoic formations of northwestern New Jersey, and collecting fossils. Of this party, Mr. Kümmel, the assistant state geologist, traces the boundaries and works out the tectonics, while Dr. Weller, of the University of Chicago, collects fossils at localities indicated by Mr. Kümmel. During July, Mr. van Ingen spent a week with this party in the field at Newton. Newton is situated on the shales of the Trenton group, there extensively quarried for slates. To the east is a low ridge of limestone which presents the same appearance as the Barnagat limestone along the Hudson river. The upper part of this limestone has yielded trilobites, probably *Dikelocephalus*, indicating that this portion is of upper Cambrian age. At other localities a trilobite described by Weller as *Liostracus jerseyensis*, shows that the rock there is also Cambrian—probably of the middle or upper division. In the vicinity of Franklin Furnace good specimens of *Olenellus* cf. *thompsoni* were found at localities described by Foerste. Further to the east of Newton, on the other side of the Cambrian ridge, is a wide belt of Ordovician rocks,—Trenton limestone overlaid by a thick series of shales. The limestone contains the typical Trenton fauna,—*Rafinesquin, Plectambonites, Pterygometopus* etc.,—and is very much like that found at Rosetown, Ulster Co., and at Rochdale, Duchess Co., N. Y. The shale has few fossiliferous beds, but occasionally one of the more sandy layers contains *Dalmanella testudinaria, Plectambonites and Rafinesquina,* the same combination found in the Hudson shales at Poughkeepsie, and at Rondout. At one locality was found a fauna with *Ampyx* and *Harpes*. In eastern New York these genera of trilobites are found only in the Chazy limestone, and the discovery is of great interest in that it indicates the presence of this formation at a distance of almost 250 miles south of what has hitherto been recognized as its southern limit. Further to the northwest, along the Delaware river, were found the Silurian and lower Devonian formations. The finest section is seen in the face of the cliff of the old Nearpass quarry, about five miles south of Tri-states where all the formations from the upper Ordovician to the Esopus shale of the lower Devonian appear, with numerous fossils. At Otisville the Shawangunk grit is finely exposed in a large quarry. All the evidence at hand points to the conclusion that this formation, of a thickness of at least a thousand feet, was formed as a flood plain deposit. Its characteristics, except color, are the same as the New Jersey and Connecticut valley Jurassic sandstones. Ripplemarks, sun-cracks, cross-bedding, channel-fillings etc., are abundant. In the railroad cut west of Otisville the grit lies upon the Hudson shales, with coincident dip. On the contact there occurs a few inches of clay, next to the shale is quite free from pebbles, while next the grit it is filled with quartz pebbles. This was interpreted to be residual clay caused by the decomposition of the shale, through sub-aërial agencies, before it became covered by the grit. The old notions regarding rock formation required the presence of a body of water in which the sediments might be deposited. Several of the geological subdivisions showed characters which would not have been present had these formations been laid down under water, for this mode of origin results in a sorting of the rock-forming materials, and no sorting is detected in these grits. Flood plain deposits are very irregular, both as to stratification and sorting of materials, and these features are well exhibited in the grits. Other formations that are probably flood-plain deposits are parts of the Potsdam sandstone in eastern New York, the Medina sandstone, the sandstones of the Catskill group, and many of the sandstones of the coal mesures of Pennsylvania and the Mississippi valley—in fact the geater part of the "barren measures."

Dr. Theodore G. White described his detailed study of the faunas of successive strata of the Lowern Ordovician in the Glens Falls, N. Y., section, and their relations to similar studies along the lake Champlain valley to the north, and the Mohawk and Black River valleys to the west. The section forms a low anticline along the shore of the Hudson. At the base is seen the Calciferous sandrock, containing *Ophileta* and fucoids. Conformable upon this is a layer a few inches thick, of barren black shale, which is very much crushed, and then the same beds of the ostracod, *Leperditia*, and their associated corals and peculiar forms of Strophomena, as have been found in the lowest Black River zones on Button island in lake Champlain. The zones of *Parastrophia* and *Triplesia* occuring near this portion of the series in localities to the north and west, were not found here. The succeeding coral beds of *Columnaria* were well developed. Above these are the cross bedded gray beds, which in some recent report have been considered to represent the Birdseye limestone, which seems to be lacking in this locality, unless met with at this unexpectedly high position. The upper portion of the section, which is of lower Trenton age, shows no unusual forms. The tendency of the lowest and the uppermost portions of the Ordovician sections in the region to wear away and appear wanting, owing to their prevailing softness, was commented on.

DR. HENRY S. WASHINGTON read a paper on "The Rocks of Lake Winnepesaukee, N. H.," as a preliminary report on work done by Prof. Pirsson and himself on mount Belknap and Red hill, near lake Winnepesaukee, N. H. The rocks of mount Belknap are shown to be prominently a quite uniform alkali syenyte, which is cut by many dikes of camptonyte and allied rocks, and of bostonytes, aplytes, and syenyte porphyries. These dikes also cut the surrounding porphyritic gneiss. At one place, near the border, is a mass of basic hornblende-gabbro, with large poikilitic phenocrysts of brown hornblende. A syenyte breccia also occurs. At Red hill similar syenyte, formerly described by W. S. Bayley, occurs on the summit, while toward the periphery, nepheline appears as a constituent, and a true foyayte is developed. The massif is also cut by dikes, both camptonitic and syenitic. The region is to form the subject of a petrographic study by the two geologists in the near future.

PROFESSOR DANIEL S. MARTIN described a visit which he paid to the noted mineral locality at Haddam, Maine, during the summer. He described the manner in which the choicest specimens occur there, in veins of albitic pegmatyte, with tourmaline, muscovite and quartz along the contact with the wall of gneiss. The mica plates along the contact are often two feet in diameter.

DR. A. A. JULIEN in his paper "The Geology of Central Cape Cod," reviewed the opinions of Mitchell, Davis, Shaler and others on the geology of cape Ann, with especial reference to the district from Chatham to Yarmouth. In the stratified deposits of sands and gravels which underlie the plains south of the morainal "back-bone" of the cape, the more frequent intercalation of clays was pointed out, and their occasional disturbance and flexure. Striated pebbles, although much water-worn, are quite largely interspersed. The discovery of true glacial silt at some depth, in one locality, indicates that the ice-sheet there rested, instead of floating. The kettle-shaped hollows and pond-basins were shown by the speaker to be largely connected with the damming of surface streams, and some observations on the pre-glacial drainage valleys and topography were discussed. The identification of certain transported fragments of quartz-porphyry with outcrops of the same near Marblehead indicates a pre-glacial movement from N. W. to S. S. E. To the fifteen changes of level which have been recorded, a final small elevation probably should be added, judging from the low terrace along this part of the coast. Examples of the [illegible] pebbles were exhibited and provoked considerable discussion among those present, as to the origin of these pebbles.

PROFESSOR RICHARD E. DODGE recounted his pleasure in visiting the gorge of the Colorado canyon, during the past summer, in company with a party and finding the physiography so graphically illustrated in the drawings in Powell's reports, to be a most faithful and non-[illegible] of the features themselves. He then described [illegible] examples of gigantic geo-physical results seen in the [illegible] the Grand Canyon itself and the Kaibab plateau and its faults. He also described the appearance of the great basin of "Lake Bonneville."

Remarks on foreign localities visited during the summer, were made by Prof. J. J. Stevenson and Dr. E. O. Hovey.

THEODORE G. WHITE,
Secretary.

A SINGLE OCCURRENCE OF GLACIATION IN SIBERIA. During three seasons' professional work in Siberia I have been constantly on the outlook for signs of glaciation. It seems almost an anomaly that in a country covered for fully half the year with snow and ice, there should be found no glacial remains. Yet such is the case, in the great majority of instances. In European Russia, north of latitude 63 degrees, glacial drift, moraines and drumlins, have been found by the Russian geologists, as indicated on their maps, although specific references to their discoveries are rare. So far as is known the glacial indications do not extend over into the great northern plain of Siberia. The numerous lakes scattered throughout, not only the Ural, but the whole of west and central Siberia have been sometimes referred to as of glacial origin. A little close observation of these bodies of water is, however, sufficient to convince anyone that their origin is due to a different cause.

In the Steppe region, lying to the south of the Trans-Siberian railway, and extending from the Ural eastward for many thousand miles, until it merges with the Great Gobi desert, there are numerous topographic features, which would, by a hasty observer, be laid to glacial origin. Small mound-like hills, frequently beautiful in their dome-like symmetry, lie scattered over the treeless undulating plain. I have been led a mile or more off my route, by a desire to examine closely such occurrences. In every case they have proved to be merely curious forms assumed by the rock itself in process of erosion. In this same region of the Steppe, the presence of numerous lakes helps to bear out the deception, but when it is found that these are merely the remnants of former and greater lakes, many of them being salt at the present day, and that they have not been dammed, but merely occupy depressions in the gently rolling prairie, the glacial supposition must of course be abandoned. The Caspian is the most tremendous example of this kind, then come the Aral sea and the Balkash lake. In the case of lake Sheero, 200 miles to the west of Minnisinsk, I noted, surrounding it successively, at various hights up to 75 feet, rings or old shore-benches, each marking a stage of the lake's history. So gradual are the slopes in the Steppe that the last and highest of these rings was at least three miles away from the present water's edge.

In a valley of the Altai mountains, on the head waters of the Tom river, there was a most remarkable case of pseudo-glacial topography. While riding up the center of the valley, I saw, making off from the steep side of the mountain, what appeared to be a glacial esker. It was perhaps 500 ft. long, 40 ft. in hight, with a width of 60 ft. and possessed the rounded, ridge-like summit characteristic of this species of glacial topography. Its side had been broken away, and from the distance, about 600 ft. at which I saw it, the appearance was that of sand. Such a phenomenon in a region in which I had looked in vain for glacial signs was a novel and startling one, and I hurried toward it to make sure. In truth the material of which it was composed was sand, and I could bury my pick to the handle end in it, but alas it was a fine even grained dioritic *greisen*, nothing else. It was in itself a remarkable form of dike weathering and interesting on that account, but as regards glaciation it was only another of the negative signs of which I had accumulated an extensive category.

The Bazaika Creek valley, about 15 miles to the southeast of Krasnoyarsk, and across the Yenesei river from that city, furnished the only evidence of a fair sized glaciated area of a former age which I have seen.

Here is an area of 100 square miles or so, enclosed by high rock walls of granite, and sedimentaries, in which, although of purely local origin, and confined to local effects, glacial conditions have obtained. Drumlins of most perfect form may be found in the bottom of the valley, near the Bazaika creek and they extend up to a hight of 600 or 700 feet on the side of the mountain. The glacial cirque topography, so common in the high Rockies, has here its development on a very large scale on one side of the valley, in such a manner that a large amphitheatre is formed, along which the creek makes its way for a distance of ten miles. At the upper end of this stream, some sixty miles from its junction with the Yenesei, it is evident that a glacier must have existed whose detritus now encumbers the valley. Near the village at the base of the valley, inside a long spur of limestone which separates the creek from the Yenesei, lies on one side a beautifully bedded sand-plain, now nearly cut through in section by the stream itself. Such occurrences as this are too rare in Siberia not to attract attention, and although I was unable to find confirmatory evidence in the form of scratched pebbles, and am therefore open to the charge of assertion on non-conclusive evidence, yet so unusual an occurrence in Siberia, a non-glacial country, deserves a mention.

In the high Altai the cirques at the head of the valleys, such as occur in Colorado, due to present freezing, melting and refreezing conditions, are common and may of course be called minute results of local glaciation. Present glaciers exist also in the Altai on the head streams of the Irtish river, near the Mongolian border. They occur, however, in mountain valleys, as in Switzerland, at hights of 10,000 feet, and are purely local in their effects.

In east Siberia, the gold-placer industry has led to a considerable study being made of the gravels which there encumber the valleys to depths varying from 10 to 150 feet. Their subangular character has led some observers to refer their presence to transportation by glaciers. From my own observations on the gravels they do not appear to me to have come from foreign sources. Their material can always be traced directly to the immediately enclosing hills. In no case have I ever found a scratched surface. The gravels are merely immense quantities of rubbish which have slid into the valleys when the mountains were of greater hight, have become covered in a comparatively short time with a carpet of turf and peat, due to the constant periodic growth and rotting of the almost tropical Siberian vegetation, and have thus lain there undisturbed, the gentle grades of the present streams not being sufficient to clear the valleys of these masses of detritus. Under any other than Siberian conditions, perhaps such thick beds of sub-angular and even angular irregularly disposed gravels might not be possible. A discussion of these conditions is, however, one that may be prolonged to a considerable length, and properly forms the subject for separate consideration.

Berlin, October, 1900. CHESTER WELLS PURINGTON.

REVIEW OF RECENT GEOLOGICAL LITERATURE.

Ueber Aulacamerella ***ein*** *neues Brachiopodengeschecht*: VON FRIEDRICH BARON HOYNINGEN-HUENE (Verhandlungen der Kaiserlischen Russischen Mineralogischen Gesellschaft zu Petersburg. Zweite (Serie. Band xxxviii, No. 1.)

On the ventral valves of two species of brachiopods from the higher Lower Silurian (Ordovicean) of the Baltic provinces Baron Huene has founded the above genus with the following diagnosis: Ventral valve more or less convex, smooth or concentrically longitudinal, keel-like median fold. Beak almost entirely atrophied. Pedicle opening unknown. Inside there is a large triangular platform, without median support, connected at the sides with the shell. Hinge border slightly raised; hinge teeth rudimentary or lacking. Dorsal valve unknown, apparently flat or concave. Two species are known. The most remarkable peculiarity of this genus is the large even platform, with a concave space underneath. In this connection comparisons are made with ***Merista*** (?) ***cymbula*** Day, and for the medium plate or septum with *Orthisina* (Clitambonites) ***diversa*** Shaler. Comparisons are also made with Camarella and Syntrophia.

Five figures in the text and a plate of figures of the two species of the new genus are given. G. F. M.

Supplement zu der beschreibung der Silurischen Craniaden der Ostseelander. By the same author and published with the former article.

This is a continuation of Baron Huene's work on the Craniadæ which appeared about a year ago and was reviewed in this journal. In this are described a number of new species, Pholadops, one species, Philhedra, five species, (and notes on two others already described), Eleutherocrania (new mut.), Pseudocrania, notes on six species already described. Pseudometoptoma, notes on two species already described.

A table of the vertical and horizontal distribution of the forms of this family is given and following this some interesting remarks on the systematic place of Pholadops. A few paragraphs also are devoted to the changes which occurred in Philhedra from its first appearance until it gave place to Craniella and Eleutherocrania in the Horizon F. 2.

There are six text figures and three plates in illustration of the species treated of in this article, which add materially to its value.

G. F. M.

A text-book of important minerals and rocks, with tables for the determination of minerals. By S. E. TILLMAN. Octavo, pp. 176, $2.00. John Wiley and Sons, New York, 1900.

After a brief account of the crystal systems, and of the common physical and chemical properties of minerals, the author gives brief general descriptions of eighty-seven minerals or groups of minerals, especially adapted to amateurs and economic mineralogists. Each mineral description is followed by a statement of the uses and localities where the mineral is most abundantly found. The tables for the determination of minerals are compact and handy, the primary divisions being based on color. They provide for the discrimination of 135 species. Part II. is devoted to a condensed description of common rocks. The work is adapted to an elementary course in mineralogy in schools and academies. It is not at all encumbered by technicalities nor by symbols.

N. H. W.

The Progress of Mineralogy in 1899, an analytical catalogue of the contributions to that science during the year. By S. HARBERT HAMILTON and JAMES R. WITHROW (Bulletin No. 2 of the American Institute of Mining Engineers, 1900.)

This publication renders a distinct and noteworthy service to mineralogy and to mineralogists. It is the only one of its kind that we know of in the English language. It is not restricted to the United States, nor to English literature, but embraces all countries and languages. It is, however, confined to literature that was received in Philadelphia prior to the beginning of 1900. It is divided into seven essential parts, each part arranged alphabetically by authors' names, viz.: New minerals, new meteorites, new elements; chemical mineralogy; new analyses, determinations, methods etc.; physical mineralogy; new forms, determinations, crystallographic studies etc.; general mineralogy; new occurrences, economic mineralogy etc.; lithology; new rocks, petrographical descriptions etc.; bibliographical, historical etc.; new books, new apparatus etc.

In order to get this literature catalogued the authors have consulted 175 different serial publications from all parts of the world, a fact which shows that a journal devoted exclusively to mineralogy should be well supported and a great advantage. Besides its own articles such a journal should annually contain such a document as this. N. H. W.

New Species of Cambrian Fossils from Cape Breton. By G. F. MATTHEW. (Bulletin, Nat. Hist. Society of New Brunswick, vol. iv, p. 219.)

Under this head Dr. Matthew has described a number of Upper Cambrian species of trilobites and brachiopods that are of considerable interest.

A good deal is made of the internal character of the shells of the brachiopods, which are carefully described. The species belong to the genera Lingulella, Lingula ? Acrotreta and Schizambon. The example of the last genus is a small species more orbicular than the type, and of interest as carrying the genus back to Cambrian time. (The typical form described by Walcott is of Ordovician age.) The Acrotreta is remarkable for the heavily truncated mould of the ventral valve, and for the unusually strong medium septum of the dorsal valves.

Among the trilobites the largest species is a Parabolina distinct from others in the strongly arched front margin of the head shield. A very remarkable form is a species of Sphaerophthalmus, carrying a very large flat genal spine, differing from S. *alatus* in this and other respects. An Agnostus of generous size is a Canadian mutation of *A trisectus* Salter; it is peculiar in having a tubercle at the end of the rachis of the pygidium, and in other respects. These trilobites are of the Peltura fauna; the brachiopods chiefly of this fauna and that of Dictyonema (*D flabelliformis*).

A plate with figures of the species and mutations described accompanies the article. N. H. W.

The Action of Ammonium Chloride upon Natrolite, Scolecite, Prehnite and Pectolite; by F. W. CLARK and GEORGE STEIGER. (*Am. J.* Sci., *160*·345-351.)

The present paper is one of a series having for an object the study of the chemical constitution of certain silicates. The minerals were subjected to the action of ammonium chloride in sealed tubes at a temperature of 350°, and the resulting products analyzed. The action of a boiling, 25% solution of sodium carbonate was also tried on them. Both natrolite and scolecite are unattacked by the sodium carbonate solution and yield with the ammonium chloride the same compound $(NH_4)_2 Al_2 Si_3 O_{10}$, which is a simple replacement of the bases and acid hydrogen of the minerals by the (NH_4) radical. From these facts and an entirely new and complete analysis it is concluded that the two minerals are salts of the same silicic acid $H_8 Si_3 O_{10}$, and that their formulæ should be written $Na_2 Al_2 Si_3 O_{10} . 2 H_2O$ for natrolite, $Ca Al^2 Si_3 O_{10} . 3 H_2O$ for scolecite instead of the previously accepted orthosilicate formulæ $Al_2 (Si O_4)_3 Na_2 H_4$, and $Al_2 (Si O_4) Ca H_4 . H_2O$ respectively. Prehnite suffers no change when treated as above and is therefore of different structure. Pectolite, a meta-silicate $Na H Ca_2 Si_3 O_9$, although attacked strongly by the chloride, did not yield results leading to any new or more definite conclusions as regards its structure.

C. H. W.

Chemical Composition of Turquoise; by S. L. PENFIELD, (*Am. J. Sci.* *160*-346:350.)

The article records a re-investigation regarding the chemical composition of turquoise. A new analysis was made on material exceptionally suitable for that purpose. From the results thus obtained the author shows conclusively that the mineral is to be regarded as a derivative of the ortho-phosphoric acid in which the hydrogen atoms are largely replaced by the univalent, isomorphus radicals $Al(OH)_2^{I}$ $Fe(OH)_2^{I}$, and $Cu(OH)_1$. The formula may be written $[Al(OH)_2, Fe(OH)_2, Cu(OH), H]_3 PO_4$. The radical $Al(OH)_2^{I}$ always predominates. A careful consideration of former analyses shows them to be in close agreement with the results just mentioned and wholly disproves Clark's interpretation that turquoise is a mixture of the molecule $Al_2H\ PO_4\ (OH)_4$ with finely divided iron and copper phosphates as impurities. C. H. W.

A new Meteorite from Oakley, Logan County, Kansas, by H. L. PRESTON. (Am. J. Sci., *160*-410 412.)

The meteorite, which is the eleventh one reported from Kansas, weighed 61 lbs. 10 oz. and was 7½ x 10 x 12 inches in its greatest diameter. It consists of "olivine and enstatite chondrules imbedded in a very irregular groundmass of the same material, with numerous particles of iron and iron sulphides." An analysis gives its composition as follows;—metallic part, Fe 12.76%; Ni + Co 1.68%; silicates, 85.56%; total, 100%. C. H. W.

Cambro-Silurian Limonite Ores of Pennsylvania; by T. C. HOPKINS (Bull. Geol. Soc. Am., vol. 11, 475-502.)

Extensive deposits of iron ores occur as irregular pocket-like deposits in the residual clays of the Cambro-Ordovician limestones and slates of eastern and central Pennsylvania. The ores consist of the hydrous oxides of iron, chiefly limonite, associated with manganese ores, wavellite, quartz, chert and fluorite. The ores appear to have been derived from the original iron content of the limestones and slates, by a leaching and concentrating process in which carbonic and organic acids together with oxygen took part. In position the ores favor the contact of the limestones and underlying slate. C. H. W.

Chemical Composition of Sulphohalite: by S. L. PENFIELD. (Am. J. Sci., *160*-425-428.)

Considerable doubt as to the existence of the mineral sulphohalite recently described and assigned the formula $3\ Na_2\ SO_4\ 2NaCl$, having arisen by reason of the failure of several investigators to make an artificial salt of like composition, the re-investigation of the species described in this article was undertaken with the result that another constituent, fluorine, was discovered and the composition represented by the formula $2\ Na_2\ SO_4\ 2\ Na\ ClNaF$ assigned to the mineral. It is interesting to note that sulphohalite was associated with another triple salt, the mineral hanksite $9\ Na_2\ SO_4\ 2\ Na_2\ CO_3\ K\ Cl$. C. H. W.

Siliceous Calcites from the Bad Lands of South Dakota; by S. L. Penfield and W. E. Ford. (Am. J. Sci, *160*-352-354, with Pl.)

The crystals are rough in appearance, but show with some distinctness characteristic calcite forms. In chemical composition the crystals resemble the siliceous calcites from Fontainebleau, containing 40% of calcite and 60 of sand. The sand grains at times attain the size of small pebbles. It appears that these crystals represent a phase of sandstone formation where the calcareous cement was able to crystalise and preserve its external crystalline form. C. H. W.

Granites of Southern Rhode Island and Connecticut, with Observations on Atlantic Coast Granites in General. By J. F. Kemp. (*Bull. Geol. Soc. Am.*, *10*, 361-382.)

All the granites described are biotite granites, muscovite, though present, being very subordinate and hornblende failing entirely. The following types are recognized: Westerly gray, Westerly red, Stony Creek red, Stony Creek gray, and Lyme pink. The Petrographic descriptions of these types and of the contact phenomena and basic inclusions as well as of the associated apatite and pegmatyte, are followed by a discussion of the chemical composition based upon six analyses, four of which are new. The silica is quite uniform, varying from 68.40 to 73.05, but with only one below 70 per cent. The Rhode Island granites run somewhat higher in lime than the Connecticut granites. The magnesia is very low in nearly every case. The soda, in relation to the potash, is relatively high in some types and low in others; while one, the red granite of Stony Creek, proves to be one of the purest potash granites on record. The paper closes with a general review of the granites of the Atlantic sea board, which are believed to belong to several different geological periods and among which the biotite granites largely predominate. W. O. C.

Contact Metamorphism of a Basic Igneous Rock. By Ulysses Sherman Grant. (*Bull. Geol. Soc. Am.*, *11*, 503-510.)

The rock referred to is the Keweenawan gabbro occupying a roughly crescentic area of about 1,000 square miles in the northeast corner of Minnesota, between lake Superior and the Canadian boundary. The contact phenomena are described only for the northwestern border of the gabbro which the author regards as probably intrusive., where it lies upon the Archæan, Keewatin and, especially the quartzyte, iron-bearing series, carbonaceous slate and graywacke slate of the Animikie. The metaporphism is very noticeable, and consists of a partial or complete recrystallization of the adjacent rocks. Complete recrystallizntiion is the rule near the contact, and in places this extends 500 feet from the contact; while a partial recrystallization is at times noticeable for two or three times this distance from the present margin of the gabbro. The rather normal metamorphic characters of the slaty members of the Animikie are first briefly noticed, and then the specially interesting contact phenomena of the iron-bearing series are more fully decribed. The original rock is regarded as having more or less iron carbonate. This rock has been widely altered by a regional metamorphism to a quartz-magnetite-amphibole slate commonly known as actinolite schist, which has in turn been profoundly changed by the gabbro, the resuling rock being a coarse-grained aggregate of quartz, magnetite, olivine or fayalite, hypersthene, augite, hornblende etc. The derivation of all these minerals, including those like olivine, augite, and hypersthene, which are characteristic of basic igneous rocks and rarely found in metamorphosed sediments, from the actinolite schist is shown to be possible; and the proofs that this contact zone really belongs to the Animikie and not to the gabbro are summarized. The contact phenomena of the Keewatin are said to vary greatly with biotite as a prominent feature. In the Archæan, the acid rocks or granites have escaped sensible metamorphism, while the basic rocks or greenstones, including gabbros, diabases and diorytes, have been profoundly altered, and usually in a way to make them difficult to distinguish from the gabbro itself. W. O. C.

Suggestions Regarding the Classification of the Igneous Rocks. By WILLIAM H. HOBBS. (*Jour. Geol.*, *8*, 1-31.)

After noting the importance of adapting the classification to the needs of the field geologist as well as the petrologist, the bearing of recent petrographical studies on rock classification, the definition of a rock as an object rather than as an integral part of the earth's crust, the importance of texture as a basis of classification, the need of combining chemical and mineralogical classifications as a basis for rock classification and of substituting quantitative for qualitative analyses, that rock relationships should be indicated by the combination of names into a binomial, or, of necessary, a polynomial nomenclature, the author introduces graphical methods as essential to a comprehensive study of rock analyses. The system of diagrams proposed by Brögger for this purpose is preferred. In these are set off on radius vectors the amounts of the eight principal chemical constituents reckoned in molecular ratios, ferrous and ferric iron being entered upon the same radius vector, and silica, because so much in excess of the others, being evenly divided between the two horizontal radius vectors. A broken line joining the intercepts on the eight radius vectors forms a polygon, which may be long and narrow, or short and thick, convex above or below, or re-entrant in any portion, left or right-handed etc., according to the chemical constitution of the rock. When viewed in this diagram the rock comes to have a handwriting by which it may be instantly recognized: and when drawn to scale the diagram not only shows the chemical character of the rock but all the results of analysis may be read from it numerically. The main purpose of this paper is to adapt the Brögger diagram to represent, not merely an individual analysis, but a rock species or type covering a considerable range of differing analyses. In other words, composite diagrams are proposed, each representing the average of a group of analyses. Examples are given for the principal types of plutonic and volcanic rocks. The possibilities of the method are farther illustrated by grouping the diagrams in natural series, which show progressive changes in form; and also by introducing a composite of each series. The numerous analyses upon which the diagrams are based are quoted in tabular form.

W. O. C.

The Nomenclature of Feldspathic Granolites. By H. W. TURNER. (*Jour. Geol., 8,* 105-111.)

Accepting the principle that the classification of granular rocks, if not of lavas, should be based on mineral composition, the author notes that this is equivalent to a classification based on molecular composition in so far as the minerals are composed each of one kind of molecules. But plagioclase is an exception, since it is composed of two kinds of molecules in ever varying proportions. The author proposes that the molecular classification be applied throughout; and hence in calculating the composition of the feldspathic rocks the plagioclase should be resolved into the constituent albite and anorthite molecules, and the name plagioclase should not be used. This is shown to be particularly necessary with the monzonytes and diorytes, which contain both orthoclase and plagioclase, since the plagioclase may vary from a basic labradorite to an acid oligoclase, thus giving rocks which could not properly be designated by the same name. It is suggested, therefore, that if we subdivide the feldspathic rocks on the basis of the ratio of the alkali-feldspar molecules (Or + Ab)g to the lime feldspar molecules (An) the true mineral and chemical relations of the rocks will be brought out and a better classification result. A graphic illustration is given in tables showing percentages of the alkalies and lime and the ratios of Or +Ab to An for the principal feldspathic types. The author further suggests the use of mineralogical terms in naming granolytes of simple composition, as orthosyte for a rock composed chiefly of orthoclase, albityte for one composed chiefly of albite etc., the names of other essential constituents to be used in substantive forms, as quartz-orthosyte or granite, and of accessory constituents in adjective form, as quartziferous syenyte etc.

W. O. C.

Some Contact Phenomena of the Palisade Diabase. By JOHN DUER IRVING. (*School of Mines Quarterly, 20,* 213-223.)

This paper, which, after noting the gradation in texture, density and mineral composition between the central and peripheral portions of this great trap sheet, is based chiefly upon the exposures of the upper and lower contacts afforded by the new tunnel of the New York Susquehanna and Western railroad, confirms in the main the work of Andræ and Osann, who in 1892 studied the lower contact only, as exposed by the West Shore railroad. The earlier work recognized four metamorphosis phases of the Triassic shale and sandstone, as follows: (1) normal hornfels, (2) the same rich in tourmaline, (3) altered arkose containing green hornblende, (4) lime-silicate hornfels. To these Irving adds five others, three from the lower contact: (1) normal hornfels rich in spinel, (2) lime-silicate hornfels containing brown hornblende. (3) normal hornfels containing "augen" and green hornblende; and two from the upper contact: (4, 5) hornfels and arkose hornfels containing richly scattered crystals of andalusite. Each type is described in detail; and the evidence is shown to strongly support the intrusive origin of the diabase, the andalusite and the fact that the hornstone a hundred feet above the upper contact is baked as hard as any below the sheet, being especially conclusive in this regard. Another contact type is believed to be a leucite hornfels, although the analysis shows it to be too high in alumina and soda and much too low in potash for a pure leucite: the discrepancy being attributed to interstitial matter. Leucite has not been previously described as a contact mineral.

W. O. C.

Ueber grosse flache Ueberschiebungen in Dillgebiet, von HERRN E. KAYSER in Marburg in Hessen. (Jahrbuch de Konigl preuss, geologischen Landesanstalt for 1900, Bohn, p. 7.)

This article describes the complicated structure of the Devonian and Culm in the neighborhood of Dill in southern Germany. A complicated series of upthrow and downthrow of faults is shown by the accompanying map, as cutting all the older formations, but not so much affecting the Culm though this formation is also cut by them. Several sections are given to show the details of the action of the force that produced these movements: and it is also shown that after the faults were produced a continuation of the movement caused the folding of the bed affected by the fault—(page 8).

Ueber den nassauischen Culm, von E. KAYSER (Neues Jahrbuch für Mineralogie etc., 1900, Bd. I, p. 132).

In this paper Prof. Kayser refers to the discovery by Tornqvist in the Posidononia slate of Hebron of a species of Meek's North American genus Euchondria (*E. europaea* Tornq.) of which he himself had found a very perfect example. G. F. M.

Beitrage zur Kenntniss des Siberischen Cambrium, I. von EDUARD VON TOLL. (Memoires de l'Acad. Imp. des Sciences de St. Petersburg, viii Ser., vol. viii, No. 10.

This quarto of 57 pages with a number of cuts in the text and eight plates of figures of the fossils described, is one of the most important contributions to Cambrian literature that have appeared in the last few years; not only on account of the thorough treatment of the subject, but also because of the distant and little known geological field whose Cambrian fossils are described herein.

Both on the Yenesei, and the Lena the great rivers of Siberia, Cambrian deposits are now known to exist, and they supply most interesting links of association with the contemporary strata on the opposite side of the world.

Very noticeable is the fulness with which the archæocyathine reef builders were multiplied in the valley of the Jenesei, and their numerous species have to a large extent been identified by Baron Toll with Bornemann's species in Sardinia.

We are startled by the reference of these archaic and puzzling forms to the calcareous Algæ. They have been bandied by various authors from one class of the animal kingdom to another. Billings, who first described them, thought they were silicious sponges, and Prof. H. A. Nicholson and Mr. Walcott supported this opinion. Bornemann who had an excellent opportunity to study the Sardinian forms, concluded that they were a special group of Coelenterata. Dr. Hinde who re-studied the Canadian species concluded that one was a lithistid sponge, and the rest were to be referred to a distinct family of the Zoantharia-schlerodermata. Meek thought Archæocyathus (Ethmopryllum) a true coral. Sir Wm. Dawson, however, thought two of the Canadian species to be Foraminifera.

Baron Toll discusses these conflicting opinions, and having described a new genus Rhabdocyathus, comes to the conclusion that through it he has reached the true solution of the zoological standing of the Archæocyathinæ, namely that they are a primitive development of the calciferous Algæ, and are related to the recent Acetabularia and the Tertiary Acicularia.

Among the material from Siberia Toll claims that he has found evidence of the embryonic stages of the archæocyathines, and figures a minute stalked cup with a detachable lid which he conceives to have been the starting point of an Archæocyathus. In his new genus, Rhabdocyathus, in which he sees a more primitive archæocyathine than in the others, the lower part of the tube has separate outer and inner walls, but in the upper part these walls come together forming a solid wall; in this genus there are no septæ, but the walls are perforate as in the others. Baron Toll regards the connecting tubules that pass from the inner to the outer wall in the archæocythines as passages for the spores, which thus escape from the inner cavity. While warmly advocating his view of the algoid relationship of the Archæocyathinæ he speaks of it as a hypothesis, thus inviting criticism of its soundness.

The earlier part of Baron Toll's work is devoted to a description of the literature of the Siberian Cambrian, in which he refers to the earlier work of Dr. F. Schmidt on a more limited collection of Cambrian fossils, from some of the localities from which the later collections came, that have been examined by Toll. Dr. Schmidt had placed some of these fossils as Devonian, but Toll correctly refers them to the Cambrian. One of these is a Dorypyge, three others are referred to the genera Anomocare. Loistracus and Solenopleura (?), (Plate II). A pygidium on the same plate referred to *Bathyurus howelli, Walc.*, has a wider flattened margin than is common in that species.

On plate I are figured a number of new species of trilobites etc., from the new localities whose fossils have been studied by Baron Toll. Two minute species which are referred to Ptychoparia might also with propriety be compared with the Strenuella type of Agraulos, and especially with *Strenuella attleborensis* S and F (Trans. Roy. Soc. Can., 2 Ser., vol. v, sec. iv., p. 77). An Agnostus of the Lœvigati group has unusual asosciations if occurring in strata with the interesting Microdiscus figured on this plate. This greatly resembles the species of this genus which occur with Olenellus; the Agnostus, however, is flatter than the typical species of the Paradoxides beds and may be an earlier form.

In this paper are described, of Ptyhoparia 1 new species. Microdiscus 2 new species, Agnostus 1 new species. *Kutorgina* (*cingulata Bill.*) and *Obolella* (*cf. chromatica* Bill.) The species are compared with those of Europe and America.

Any claim that Agnostrus occurs in strata below Paradoxides requires to be well supported. The type of the one that Ford thought he found at Troy, N. Y., is lost and the figure he gives scarcely supports the reference to this genus. Baron Toll thinks that *A. atavus* of Tullberg may be claimed for the Olenellus zone; but while Tullberg refers the group of strata in which it was found at Andrarum to the Olenellus zone, Olenellus (i. e. Holmia) is found only in the lower part of this set of beds, and Tullberg reports a Paradoxides in these beds *below* the layer which carries *Agnostus atavus.*

Descriptions and figures of F. Schmidt's species are given and a very full account of occurrences of the several forms of the Archæocyathinæ.

Table C (p. 55) is an endeavor to show diagrammatically the chronological relation of the several parts of the Siberian Cambrian, and the author's view of the bearings of the several groupings of species, and the nature of the sediments, on the probable depth of the Cambrian sea at the time these creatures of the Cambrian age were entombed.

In conclusion we may congratulate the author on having rescued from the unknown a new chapter of geological history, and on having placed us at a new point of view, from which we may regard the activities of the Cambrian reef-builders. G. F. M.

La Face de la Terre (*Das Antlitz der Erde*), par ED. SUESS, traduit avec l'autorisation de l'auteur et annoté sous la direction de Emmanuel de Margerie. Tome II, Paris, 1900.

This well-known classic on the physical features of the surface of the earth is considerably enlarged by original notes and references to later literature. This tome begins with the "third part," the seas. After a full description of the Atlantic and Pacific ocean, and a comparison of one with the other, the author enters upon the discussion of paleozoic seas, thus coming within the domain of geology proper. Here is abstracted and epitomized the result of all the study of the paleozoic both in America and Europe. The Mesozoic seas are treated in the same manner, then the Tertiary seas. In chapter VIII the author discusses the shore lines of Norway, their possible elevation, the glaciers and fjiords. A history of the temple of Serapis at Pouzzoles, as affected by earth movements, and by volcanic ejection, as well as the results of exhumation and its present state are included in chapter IX. The Baltic and the North seas during the historical period, and the Mediterranean during the same period, are subjects of long inquiry and important description. The work closes with a chapter devoted to the shore lines of the northern seas.

This work thus covers the whole field of modern geology, and brings within small compass the grand conclusions of the science on the main features of the history of the stratified rocks. The collaborators with M. Margerie, in this translation and in the new ma- Six and M. Zimmerman. The new French edition of this German treatise renders a great service to geologists in bringing it within terial, are Aug. Bernard, Ch. Depéret, W. Kilian, G. Poirault, Ach. reach of a wider circle of students. The only criticism that may be made is one that is a common fault of French works, viz: it has no index, and only the most general subdivisions and running heads. It is therefore much like a hidden mine which everyone must explore independently, without guides. English, and especially American, scientific books are far ahead of those of continental Europe in this particular. N. H. W.

A Record of the Geology of Texas for the Decade ending December 31, 1896. By F. W. SIMONDS. (Transactions of the Texas Academy of Science, vol. 3, pp. 1-280. Austin, August, 1900.)

This record begins where professor Hill's Bulletin No. 15 of the United States Geological Survey leaves off, and covers the decade which, as remarked in the author's prefatory note, has been more fruitful of results than any other and has placed the geology of Texas upon a solid foundation, notwithstanding the many details that remain to be worked out and errors that must be corrected.

It comprises 466 titles, numbered for convenient cross and index-reference, arranged alphabetically by authors, those of each author being arranged according to time of publication.

The entry of copious quotations, judiciously selected to show progressive or important features of most of the papers cited, and the preparation of brief abstracts of certain papers or parts of papers, have more than doubled the value of the record as a bibliographic production. In presenting these Dr. Simonds has been wisely impartial, avoiding entanglement in controversial geology and letting the principal results and contentions of authors speak for themselves.

Lists of fossils, minerals and rocks newly described or illustrated, or of which new knowledge is added in the papers cited, faunal lists of formations, condensed geologic sections, chemical analyses and economic statistics have been freely included.

Thus, in a form compact and convenient for reference, the *Record* embodies the best part of the known geology of Texas, and constitutes an admirable handbook of the latter and one that will be indispensable to all future students of the geology of the state or of North America at large.

Typographical errors do not recur with sufficient frequency to be burdensome.

An excellent index is provided, embracing topics, localities and authors. F. W. C.

Bulletin of the Hadley laboratory of the University of New Mexico. Vol. II, part 1, 1900. Published with the cooperation of Mrs. W. C. Hadley.

This publication embraces several articles, the leading one being devoted to the geology of the "Albuquerque sheet," of the United States Geological Survey, with the limits of which lies the territorial university. Its authors are C. L. Herrick and D. W. Johnson It is accompanied by a map and thirty-two plates, mostly of fossils, of which fourteen are new or undetermined. The article gives a convenient synopsis of the geological structure of the area included in the Albuquerque sheet, with incidental references to the surrounding country. The Tertiary forms a large central triangular mesa, extending from the Rio Grande to the Puerco, with a gentle general dip to the southeast. Volcanic rocks forming cones and flows pierce and lie upon the Tertiary, the most notable being the volcanoes a short distance west from Albuquerque. These are believed to be a part of a series that runs north and south, indicating a line of weakness and perhaps of fracture and faulting. It is interesting to note that some specimens of maize embraced in what was supposed to be a part of this lava were traced to a recent artificial origin, the "lava" being simply fused adobe, a part of an abandoned brick kiln. Thus the idea that man was contemporary with the lava was abandoned.

The Sandia mesa rises from the Rio Grande toward the east. The inclination is much increased near the Sandia range of hills a spur from which enters the area of the sheet. These hills are due to a great fault which has brought to the surface the Permian and Carboniferous the uplift being on the east side of the fault. This dynamic movement was accompanied by metamorphism and apparently by fusion of the rocks concerned, giving vent to granite.

In the Cretaceous of the western part of the area are lignite beds which have been considered Laramie but they lie below the Fox Hills of the Cretaceous. Some pre-Tertiary igneous rocks that pierced the Cretaceous and modified its beds, are found near the Puerco valley, west of Albuquerque, in the form of isolated trachyte cones, the surface lavas of which had apparently been eroded and lost prior to the Tertiary covering which has since been also removed by the erosion incident to the Puerco valley. The authors gave the petrographic characters of these rocks and of the Tertiary basalt.

Short paragraphs are devoted to the building materials, and especially the clays, and to irrigation.

Pres. Herrick also discusses in a short article the possibilities of salt, gypsum, cement, clay and graphite, in New Mexico.

The volume also contains "Report on a geological reconnoissance in western Socorro and Valencia counties, New Mexico," and "Identification of an Ohio Coal Measures horizon in New Mexico." which have appeared in the American Geologist; also "The Geology of the White Sands of New Mexico," from the Journal of Geology, and closes with "The Cyanide process in New Mexico" by V. V. Clark.

The publication indicates great activity and energy on the part of Dr. Herrick, who has produced this and the preceding bulletin in addition to his duties as president of the Territorial University. Such a publication must be one of much convenience and value to the people of the territory. N. H. W.

The Geology of Eastern Berkshire County, Massachusetts, B. K. EMERSON. (Bull. 159, U. S. G. S.)

This bulletin is supplementary to the Housatonic folio, and treats of the area adjoining the Green mountain and Hoosac mountain regions, which have been the subjects of recent monographs.* The bulletin consists principally of lithological and petrographical descriptions.

The region described represents the central portion of a deeply eroded mountain region. It presents a complicated series of much folded and faulted pre-Cambrian and early Paleozoic rocks. Mr. Emerson distinguishes and describes six gneisses, three limestones, three schists and one quartzyte. He concludes with a lexicon of Berkshire county minerals.

The bulletin is somewhat fragmentary. It does not give a complete history of the region nor discuss any of the larger problems involved. Doubtless the Housatonic folio will treat of this side of the subject and as an appendix to the folio the bulletin will be of value. I. H. O.

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OF AMERICAN GEOLOGICAL LITERATURE ARRANGED ALPHABETICALLY.

Bather, F. A.

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A remarkable occurrence of Orthoceras in the Oneota beds of the Chenango valley, N. Y. (Bull, No. 39, vol. 8, N. Y. tate Mus., pp. 167-170, plates 1-4, Oct., 1900.)

**Geology of the Green Mts. in Massachusetts,* by Pumpelly, Wolff, Dale. Mon. U. S. G. S. XXII.

Moore, Joseph (W. G. Middleton and)

Skull of fossil bison. Proc. Ind. Acad. Sci., 1899, pp. 178-181. Indianapolis, 1890.)

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Correlation between Tertiary mammal horizons of Europe and America, parts 1 and 2. (Annals N. Y Acad. Sci., vol. 13, pp. 1-72, July 18, 1900.)

Perkins, Geo. H.

Report of the state geologist on the mineral resources of Vermont, 1899-1900, pp. 83, plates. Burlington. 1900.

Rand, Theo. D.

Notes on the Geology of southeastern Pennsylvania. (Proc. Acad. Nat. Sci., Philada., Feb., 1900, pp. 159-338.)

Sardeson, F. W.

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Scovell, J. T.

Terraces on the lower Wabash. (Proc. Ind. Acad. Sci., 1898, pp. 274-277. Indianapolis, 1899.)

Simpson, Geo. B.

Preliminary descriptions of new genera of paleozoic rugose corals. (Bull. No. 39, vol. 8. N. Y. State Mus., pp. 199-222, figs. 1-45, Oct., 1900.)

Sollas, W. J.

Evolutional geology. II. (Science, N. S., vol. 12, pp. 787-796, Nov. 23, 1900.)

Turner, H. W.

The Pleistocene Geology of the South Central Sierra Nevada with special reference to the origin of the Yosemite valley. (Proc. Cal. Acad. Sci., 3rd Ser., vol. 1. No. 9. pp. 261-320. pls. 31-39. Dec. 1, 1900.)

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A Tertiary coral reef near Bainbridge, Georgia. (Science, N. S., vol. 12, p. 873, Dec. 7, 1900.)

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On some additional or imperfectly understood fossils from the Cretaceous rocks of the Queen Charlotte islands, with a revised list of species from those rocks. (Geol. Sur. Can., Mesozoic Fossils, vol. 1, Part IV, pp. 263-307, pls. 33-39, Nov., 1900.)

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Mineralogical and Petrographic study of the Gabroid rocks of Minnesota, and more particularly of the Plagioclasytes, III, IV. (Am. Geol., vol. 26, pp. 261-307, Nov., 1900; ditto, Am. Geol., vol. 26, pp. 348-388, Dec., 1900.)

PERSONAL AND SCIENTIFIC NEWS.

The famous Clarence S. Bement collection of minerals which has attracted mineralogists from all over the world to Philadelphia for so many years, when they wished to see some of the finest specimens known, has been purchased by the friends of the American Museum of Natural History and has been presented to that institution. The donors' names are withheld from the public at present, though this is the largest and most valuable single gift ever made to the museum. The minerals in the collection are said on good authority to have cost Mr. Bement not less than $150,000, while the meteorites contained in it are said to have cost an additional $50,000. This great acquisition places the mineral collection of the North American Museum on a footing comparable with that of the greatest collections in Europe, and the meteorite collection is probably surpassed only by those at the British Museum and the Royal Museum at Vienna. The collection arrived at the museum during the last week of the old year, has been unpacked and its installation is proceeding as rapidly as possible. The old museum collection has been relegated to drawers for the present, but eventually the two are to be consolidated.

Prof. Henry Fairchild Osborn has resigned his position as assistant to the president of the American Museum of Natural History, in order to have time to attend to his new duties as vertebrate paleontologist to the United States Geological Survey. He retains, however, the curatorship of the department of vertebrate paleontology in the museum, and will continue as heretofore the building up of the collection the assembling of which has been under his direction for the past ten or eleven years.

PROF. H. C. BUMPUS, OF BROWN UNIVERSITY, has been called to the position in the American Museum left vacant by Prof. Osborn, and he assumed office as "assistant to the president" on the 1st of January. Recent invertebrates have been taken away from the department of geology and reptiles and fishes from the department of vertebrate zoology and erected into a new department, of which Prof. Bumpus has been made curator.

The old department of geology has been further subdivided by constituting a new department of mineralogy, of which Mr. L. P. Gratacap has been made curator. Mr. Gratacap also retains charge of the recent shells, of which he has had the care for several years. Prof. R. P. Whitfield remains curator of the reorganized department of geology and invertebrate paleontology, which these changes restore to the scope which it had when he came to the museum more than twenty-three years ago. Dr. E. O. Hovey, who has been assistant curator in the department for seven years, has been advanced to be associate curator.

GEOLOGICAL SOCIETY OF WASHINGTON.—The following was the program for the meeting on January 9th: N. H. Darton, "Comparison of the Geology of the Black Hills with that of the Front Ranges of the Rocky Mountains;" A. H. Brooks and A. J. Collier, "Glacial Phenomena in the Seward Peninsula, Alaska;" A. C. Spencer, "The Physiography of the Copper River Basin, Alaska."

A SKETCH OF DR. LUCIUS LEE HUBBARD, former state geologist of Michigan, is given in the Michigan Miner, vol. 3, No. 1, Dec. 1, 1900. The sketch is accompanied by a photograph and was written by Dr. Alfred C. Lane, the present state geologist.

A new "Geological Review" has been established in Germany, edited by Dr. K. Keilhack, at Berlin, published by Borntraeger Brothers, at Leipzig. The first number is dated Jan. 1, 1901, has thirty-two pages and embraces reviews of geological contributions from all parts of the world, printed in German, French and English. The American co-editors are F. D. Adams, H. M. Ami, W. H. Beal, E. Böse, W. M. Davis, F. P. Gulliver, Eugene Hussak, F. H. Knowlton, H. B. Kümmel, C. Palache, H. Ries, R. D. Salisbury, T. W. Stanton, and J. E. Wolff. There are sixty-three other co-editors. G. E. Stechert, New York, agent. Subscription, 30 marks.

THE DEPARTMENT OF GEOLOGY AND GEOGRAPHY AT HARVARD UNIVERSITY will move at the en dof this college year into the new wing of the University Museum, now being constructed for its use. This will relieve it from the cramped quarters which it has occupied for so long.

On Nov. 16 and 17 a party of Harvard students and instructors returned the visit of their Yale fellow workers. Friday afternoon was spent in visiting the museums in New Haven, the evening in social and scientific conference, and Saturday was given to trips to regions of geological interest near.

The first year men in research, in the Division of Geology at Harvard University are engaged in a very detailed survey of the Middlesex Falls, under the guidance of Dr. T. A. Jagger, Jr. This is on a larger scale than heretofore ever attempted. The contour map of the Metropolitan Park Commission is used as a basis. The area of survey is to be gradually extended.

Professor J. W. Gregory, of Melbourne, Australia, passed through the country in November, on his way to London to arange for a boat for the British Antarctic epedition, which is to start next summer. He made short stops at Chicago and at Cambridge, to meet the geologists there and look over their equipment.

Geological Society of Washington. The annual meeting for the election of officers was held on December 19th. At this meeting Mr. Whitman Cross gave the presidential address on "The Development of Systematic Petrography in the Nineteenth Century." At the meeting of December 12th the following program was presented:

C. W. Hayes:—Geological relations of the Tennessee brown phosphate.

Lester F. Ward:—The autochthonous or allochthonous origin of the coal and coal plants of central France.

E. E. Howell:—Exhibition of a geologic relief map of the United States.

The Petrographical Reference Collection of the U. S. Geological Survey at present numbers over 1,000 specimens, with complete card indices, and is now available for the use of petrographers. It is hoped soon to issue a descriptive circular for the information of all to whom such a collection may be of value. One of the features of this collection is the valuable series of the igneous rocks of the Christiania region which Prof. W. C. Brögger brought to this country when he came last spring to deliver the George Huntington Williams memorial lectures at Johns Hopkins University.

Mother Lode District, California. The United States Geological Survey has recently published Folio No. 63 of the Geological Atlas of the United States designated the "Mother Lode Survey District Folio, California."

The folio comprises two sheets of topographic maps, on the scale of one mile to the inch (1-63, 360), embracing an area six and one-quarter miles wide and about seventy miles long, two sheets showing the relation of the mining claims to topography and geology, two sheets illustrating the areal and economic geology, and two sheets of structure sections.

In the eleven pages of descriptive text, signed by F. L. Ransome, geologist, there is presented a concise and simple statement of the general geological features of the district. The history of the events which led up to the present geological, economic, and topographic relations is also briefly told.

The gold-quartz veins, which give to this region its chief importance, are discussed with reference to origin, structure, and relations to the inclosing rocks. This general account of the auriferous lodes is followed by brief notes on the prominent mines. The resources of the district, other than gold, are treated at lengths proportionate to their relative importance. The more important results derived from the investigation of the district, especially those which may be of value in its future economic development, are finally gathered together in a terse summary.

THE WASHINGTON ACADEMY OF SCIENCES is preparng a new directory of the membership of the Academy and of its nine affiliated societies. This will conform in general character to the directories of the scientific societies of Washington, D. C. heretofore published.

MR. T. C. WESTON has written and published a volume giving reminiscences of his thirty-five years connection with the Geological Survey of Canada, which began in 1859 and ended in 1894. These pages recall men who have been noted in Canadian geology—Logan, Hunt, Billings, Richardson, Barlow, Murray and others.

THE COLLECTION OF DUPARC'S GREAT RELIEF MODELS of structures of the Alps includes one that shows the Glarner double fold according to A. Heim. Others illustrate vividly symmetrical and unsymmetrical anticlinal folds; inverted arches and anticlinal folds and other interesting mountain structures. This collection of eight models in plaster of Paris was displayed at the Swiss national exhibition at Geneva, in 1896. It is one of the most important series available for museums or lecture-rooms. The cost is $100.

GRANITE MONOLITHS are being quarried at Vinal Haven, Maine, for the cathedral being built at Morning side Park, New York. Thirty-two of these columns are required to be 54 feet long and 6 feet in diameter, each weighing 160 tons, or two-thirds as much as Cleopatra's needle in Central Park. For dressing and polishing these granite columns they are mounted in a giant lathe and revolved so as to bring their exterior surface first against cutting tools and afterward on polishing materials. This lathe is 86 feet long and weighs 135 tons, and the rough stone which it reduces to dimension, weighs at first as much as 310 tons. This lathe was designed and patented by engineers of Boston, and was constructed in Philadelphia.—(*Sci. Am.*)

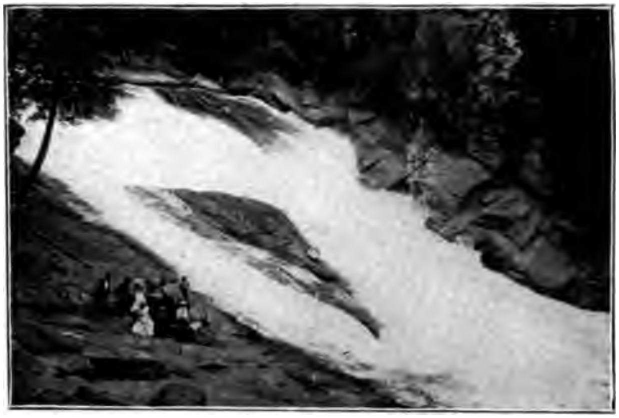

Fig. 1. VIEW IN THE GORGE, SHOWING THE JOINT STRUCTURE OF THE SCHIST.

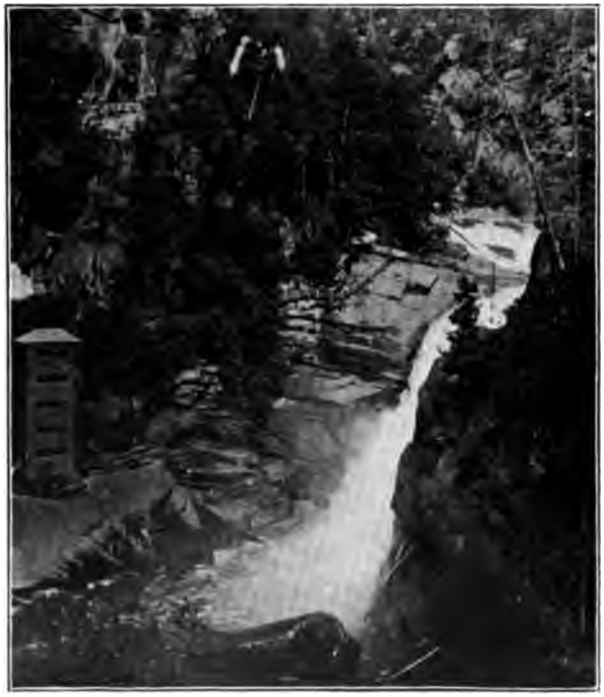

Fig. 2. A TYPICAL VIEW IN THE GORGE.

AMERICAN GEOLOGIST.

Vol. XXVII. FEBRUARY, 1901. No. 2.

THE GEOLOGY OF THE TALLULAH GORGE.

By S. P. Jones, Vanderbilt University, Nashville, Tenn.

PLATES IX-XI.

Introductory and general description.

In papers of a physiographic nature the Tallulah gorge in northeastern Georgia has been incidentally mentioned by different writers a number of times.

Nothing on it per se, however, has ever appeared, with the exception of an article of a rather general character by Dr. W. L. Jones, formerly professor of geology at the University of Georgia, published in the *Atlanta Journal* about 1892.

An opportunity was afforded the writer during the past summer to examine the region in detail, and the following paper is offered as a small contribution to the geology of Georgia.

The Tallulah river rises in western North Carolina just above the Georgia line, flows in a southeasterly direction through Rabun county in the extreme northeast corner of Georgia and, uniting with the Chattooga at the South Carolina line, forms the Tugaloo, a tributary of the Savannah.

Its entire course is within the Blue Ridge mountains, the easternmost of the southern Appalachians, its flow being down the southeastern slope and approximately at right angles to the axis of the range.

By reference to the accompanying topographic map (Plate X.) it will be seen that all the streams in the region under consideration have dissected deep valleys, while the more prominent peaks and ridges exhibit a close correspondence in altitude along a northeast southwest direction, with a fairly uniform increase in hight from the southeastern foothills to the crest of the range. It will also be noticed that the head waters of Panther creek, which empties in the Tugaloo a few miles below the mouth of the Tallulah, and those of Glade creek, a tributary of the Chattahoochee, are within less than a mile of each other with a low divide between them.

The investigations of geologists most familiar with the southern Appalachians have shown that the greater portion, if not all, of the province has been twice base-leveled—once during Cretaceous and once during Tertiary times.*

In the region around Tallulah falls, however, considerable areas seem not to have been reduced to base level and, owing to close proximity in altitude and other complicating conditions, the differentiation of the two peneplains in northeastern Georgia is not easy.

For the last four miles above its confluence with the Chattooga the Tallulah river cuts through the southeastern side of a series of broken ridges called the Tallulah mountains and it is here that the gorge and falls of the same name are located.

In the region of the gorge the river has a normal flow, as determined by Mr. B. M. Hall, hydrographer for the U. S. Geological Survey, of about 180 cubic feet per second.

The town of Tallulah Falls is on the western side of the river three miles above its mouth and an iron bridge, convenient in locating positions, spans the gorge on the road to Clayton, Georgia.

The gorge begins about a mile and a half above this bridge and runs all the way to the mouth of the river. From here it may be considered as being continued by the Tugaloo for about two miles.

Above the gorge the Tallulah presents the usual characteristics of a rapid flowing mountain stream with steep slopes on either side and sufficient valley land at places to afford small farm settlements. Below the gorge the Tugaloo presents a similar aspect characterized, however, by broader al-

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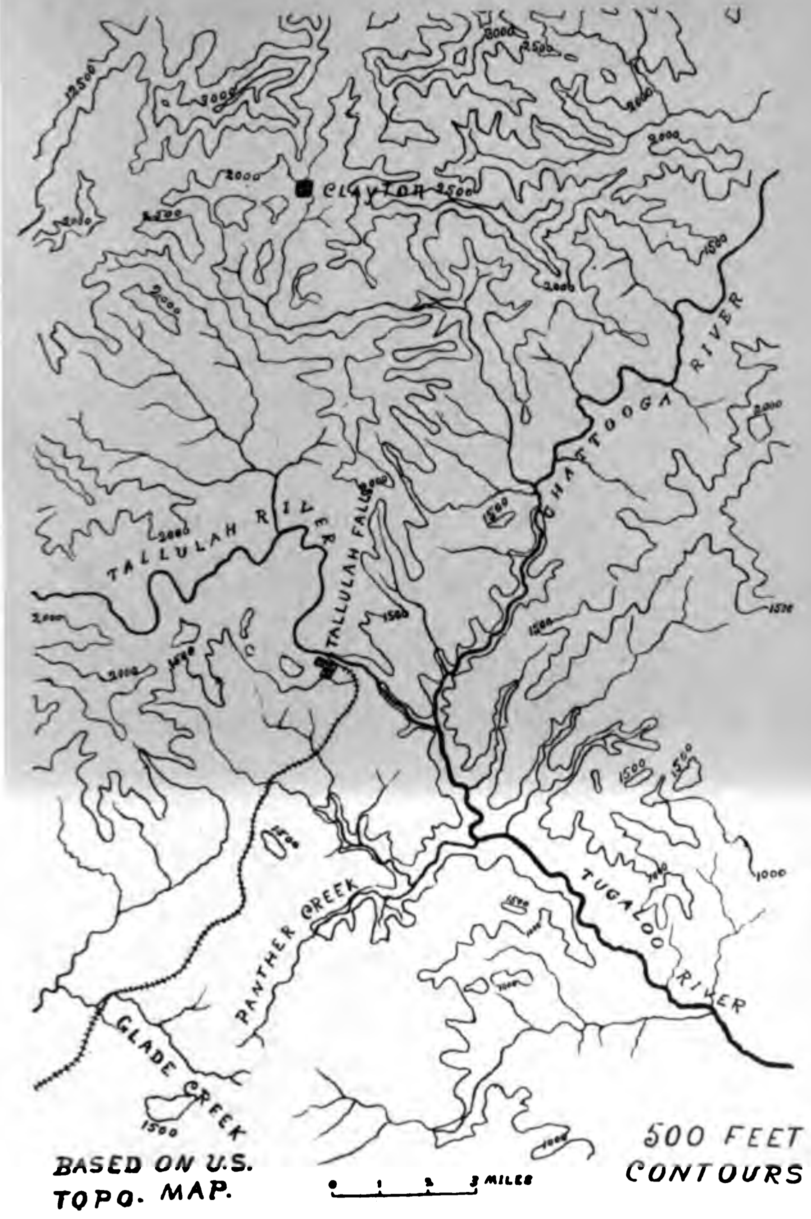
*C. W. HAYES, and M. R. CAMPBELL, Geomorphology of the Southern Appalachians. *National Geographic Magazine* 1894, vol. vi, p. 63-126.



TOPOGRAPHICAL MAP OF THE REGION OF THE TALLULAH RIVER.

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LENOX AND
ATIONS.

luvial borders and a more rounded contour of adjacent hills as it approaches the Piedmont plain.

The falls occur in a section of the gorge three-fourths of a mile long beginning half a mile below the bridge. Named in succession, they are: L'Eau d'Or, Tempesta, Hurricane, Oceana and Bridal Veil. None has a vertical fall of over ninety feet, though the total descent of the river from the first to the last fall is about 360 feet.

At the Indian Arrow rapids, just above the falls, the river is a hundred feet below the principal street of the town, somewhat arbitrarily assumed as the level of the upper edge of the gorge at this point. From here the gorge deepens and widens rapidly, reaching its greatest depth in the neighborhood of the horseshoe bend, in the portion below the falls termed the Grand Chasm. Here the gorge is 530 feet deep as measured from the roadbed of the Northeastern Georgia R. R., which runs for a short distance along the brink of the chasm. Reference to the accompanying map and profile (Plate XI.) of a portion of the river will bring out these points more clearly.

From the Grand chasm to the junction of the two rivers the gorge is somewhat shallower and with less definitely defined walls than in the region just described, some strips of cultivated land bordering each side of the river near its lower end. It is in the region of the falls and Grand chasm that the typical gorge character is best developed and it was doubtless the wild, rugged scenery of this portion that suggested the Indian name "Tallulah" or "the terrible."

Geological Features.

Tallulah falls is situated within the region designated on any geological map of Georgia as the "Crystalline Area."

This formation embraces all the northeastern portion of the state and is made up principally of granites, gneisses and crystalline schists.

The exact position of these rocks in the geological time scale has never been determined. They are generally classed as pre-Cambrian.

In the small geological map accompanying this article (fig. 1.) three areas are shown—a quartz schist formation, a narrow belt of limestone and a biotite schist on either side of the limestone. The first merits special description, the gorge being confined to it.

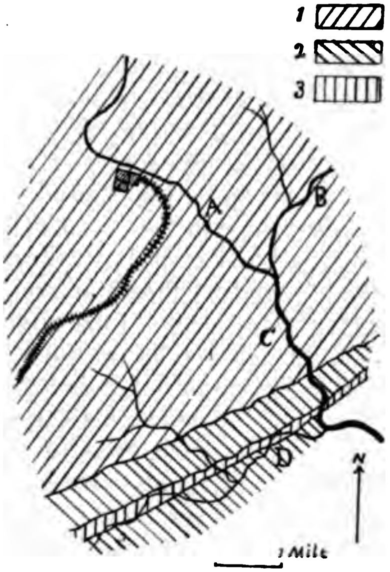


FIG. 1. 1 Quartz schist; 2 Biotite schist; 3 Limestone; A Tallulah river; B Chattooga river; C Tugaloo river; D Panther's creek.

This quartz schist, as far as mapped, exhibits an unusually well developed joint structure one of whose planes corresponds closely with the schistosity dip which is about 25° in a direction south 20° west.

If this schist was derived from pre-existing sedimentary rocks, as seems probable, the strike of the true bedding planes, which have since been obliterated in the perhaps several times repeated metamorphism of the region, must have corresponded with that of the limestone belt which, as can be seen from the map, makes a large angle with the schistosity strike.

The course of the Tallulah, and indeed of all the streams in the region under consideration, seems to show no evidence of close adjustment between the flow of the rivers and the dip and strike of the rocks.

Figures 1 and 2, plate IX. show very well the joint structure mentioned above and the relation of the river to the rock.

Megascopically the schist is a gray, medium grained, compact rock and exceedingly hard under the hammer. The schistose structure is not conspicuous in unaltered specimens, but shows plainly wherever weathering has taken place. Irregularly distributed masses of pyrite are quite abundant and on all exposed surfaces the iron oxide stain resulting from their decomposition is characteristic.

Under the microscope the rock is seen to be composed principally of quartz; this material probably amounting to 90° of the whole. Feldspars are next in abundance, muscovite probably next, pyrite, some biotite, occasional grains of magnetite, small crystals of apatite and a few isolated masses of some irregularly shaped, highly refractive substance showing low double refraction and giving no very satisfactory indications as to its nature.

The quartzes are in the form of irregularly shaped grains closely interlocked, many showing wavy extinction and all more or less shattered, with the cracks filled with subsequently deposited silica. Nothing in the nature of a zonal structure or anything indicating original sedimentary material is to be found, but owing to the evident crushing and metamorphism that has taken place this can only be regarded as negative evidence with reference to such a possible origin.

Of the feldspars, microline and plagioclase are the most abundant with some perthitic intergrowths of orthoclase and plagioclase. Much of the feldspar is broken and cracked like the quartz, but not to so great an extent.

Some of the muscovite has undergone alteration and is accompanied by granular epidote.

The biotite is frequently accompanied by sheaf-like masses of minute needle-like crystals showing very high interference colors—doubtless rutile. A chemical determination of the amount of silica present would enable the rock to be classified with greater certainty.

At several points along the gorge thin seams or lenticular masses of intercalated, highly graphitic margarite schist carrying crystals of tourmaline are noticeable.

The limestone and biotite schist may have possibly had some influence in determining former drainage, but present no special features for present consideration.

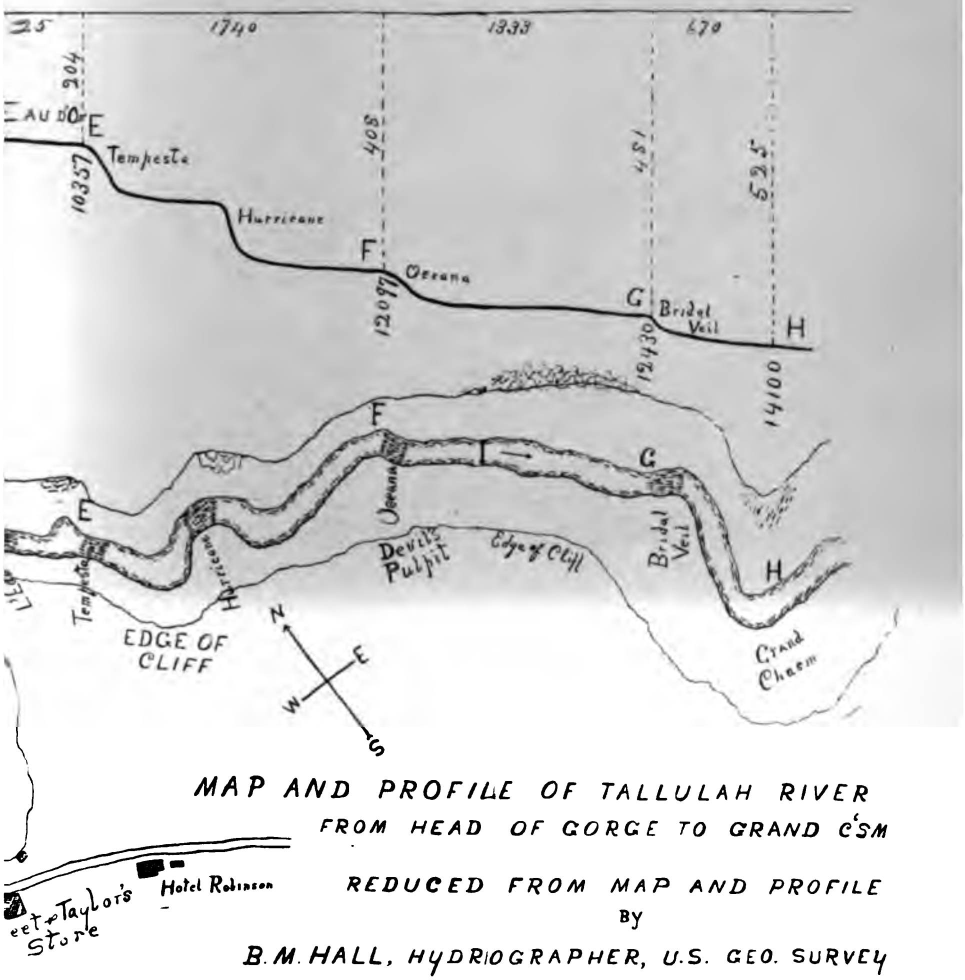
Origin of the Falls and Gorge.

Detailed examination of the gorge and river with related topographic features brings out clearly two important facts —1st, that the gorge has been produced entirely by the erosive action of the river, assisted by atmospheric agencies, and, 2nd, that both the falls and gorge are, geologically speaking, of very recent age.

Evidences of marked stream erosion are everywhere visible along the margin of the river in the upper part of the gorge. At the Indian Arrow rapids, above the falls, the river has, by deflection and concentration of its flow, on the left bank exposed on the west side a considerable portion of bed rock, now a yard or more above normal water level. An instructive display of pot-holes is to be seen here in the hard, polished rock, some of them four or five feet in diameter and deeper than broad. A little farther down stream on the right bank a large pot-hole can be found about two yards above water-level, partially filled with decayed rock and vegetable mould and having in it the stump of a tree five or six inches in diameter. The absence of similar evidences of stream action along higher levels is to be noted and is due to the widening of the gorge that has taken place through atmospheric agencies. The well developed joint structure of the schist has greatly facilitated the rapid action of these agencies in a climate where alternate freezing and thawing is frequent during the winter season, and the tumbling in of large blocks has produced a recession of the walls of the gorge probablv pari passu with the down cutting of the stream. Also the rock, though of a hard flint-like texture, weathers rapidly in the moist air of the gorge, the decomposition of the pyrite and feldspars allowing the quartz grains to fall apart. The greater width of the lower portion of the gorge bears testimony to its greater age and the longer continued action of these forces. The comparative youth of the gorge is indicated by the steep grade of the river and the presence and character of the falls as well as by the steepness of the walls.

The immediate location of the falls is not a permanent one, but they are constantly working up stream at a rate that may be rapid enough to admit of measurement, though inquiries

PLATE XI.



MAP AND PROFILE OF TALLULAH RIVER

FROM HEAD OF GORGE TO GRAND C'SM

REDUCED FROM MAP AND PROFILE

BY

B.M. HALL, HYDRIOGRAPHER, U.S. GEO. SURVEY

[illegible]

among the old inhabitants of the neighborhood failed to throw any light on this point. There is nothing, however, to indicate that they have migrated from a definite, initial position as in the case of a fall like Niagara working back by undermining. Indeed, the presence of a number of sloping falls (they are all more or less sloping) instead of a single vertical one would preclude the idea of any such origin. They are rather to be looked upon as rapids or shoals of an accentuated type where the grade of the river is steepest in its course to the lower level of the Tugaloo.

Mr. C. W. Hayes thinks that the Chattooga river and the tributary Tallulah have been captured and diverted from the Chattahoochee to the Savannah drainage system by the Tugaloo and that the falls on the Tallulah show that the Tugaloo has not yet had time to subdue the recently acquired territory.* Mr. M. R. Campbell has also advanced views of a similar nature.†

As both these writers consider a case of stream piracy to have taken place here, the origin of the gorge will first be considered on such a supposition.

From the top of any prominent peak east of Tallulah river in the region of the gorge a long even-crested ridge, the Chattooga ridge, can be seen on the southeastern side of the Chattooga. A natural continuation of this is seen west of the Tallulah in the region of Panther creek, while a deep gap, through which a broad vista of the low country is observed, marks the position of the Tugaloo. If a capture took place it was probably at a point a short distance above the mouth of Panther creek; the Chattooga originally continuing its course to the Chattahoochee along the valley of Panther creek and its west fork, the present reversed drainage of this creek being necessarily brought about by the lower grade of the Tugaloo. The divide between the western fork of this creek and several creeks tributary to the Chattahoochee is at its lowest point between 300 and 400 feet above the present level of the Tugaloo at the juncture of the three streams, and Chattooga.

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* C. W. Hayes. The Southern Appalachians, *Monograph*, National Geogra Society, 1896, vol. i, p. 327.

† M. R. Campbell. Drainage modifications and their interpretations. *Journal of Geology*, 1896, 4, 657-678.

While there is no way to measure the erosion that has taken place at this point since the supposed capture, nor the relative rapidity of the lowering of the land here, as compared with the lowering of the bed of the Tugaloo, yet as it is now the divide between the two creeks and is undergoing considerable erosion, it is not unreasonable to suppose that at the time of capture it was as much as 500 feet above the present level of the Tugaloo at the jucture of the three streams, and that the grade of the Chattooga at that point, and therefore necessarily at the mouth of the Tallulah, was before the capture that much above its present level at the mouth of the Tallulah.

From an examination of the profile of the Tallulah, as shown on the map (Plate XI), it will be seen that a line of level from the river bed at the head of the gorge to the Grand Chasm is 525 feet above the river at the latter point, or approximately coincides with the brink of the cliff at its highest point. In other words, if the Chattooga was once 500 feet above its present level where it is joined by the Tallulah the latter river could have reached it by an easy grade without having had to cut a gorge. On the capture, however, of the Chattooga at a point a short distance below the mouth of the Tallulah by the Tugaloo, the grade of the first named river would have been lowered sufficiently to necessitate the cutting of the gorge through which the Tallulah now flows. Careful search in the region across which the Chattooga would have had to flow failed to reveal anything like river gravel, but subsequent erosion may have entirely obliterated the old stream bed.

The theory of capture has lately received corroborative evidence from a comparative biological study showing similarity in a portion of the unione fauna of the Chattahoochee and Savannah rivers.[*] There is also some evidence of forms in the Savannah system that point to a round-about derivation from forms of the Tennessee river through former connection between it and the Coosa river in Alabama and between the Coosa and the Chattahoochee by way of the Etowah in Georgia, and from the Chattahoochee to the Savannah system by former connection at the locality under consideration.[*]

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[*] Chas. T. Simpson. On the evidence of the Unionidae regarding the former courses of the Tennessee and other Southern rivers. *Science*, vol. xii, No. 291, p. 133.

If the Chattooga originally belonged to the Savannah system, and no change of position has taken place, then the next theory that would seem to suggest itself as explanatory of the evident recentness of the gorge cutting would be that the differential movements that are known to have taken place at the end of the Columbia and LaFayette in some way caused particular activity in stream erosion at this locality.

Under either theory, however, the absence of a gorge of similar character in the adjacent Chattooga would appear to need explanation.

PALEONTOLOGICAL SPECULATIONS.

L. P. Gratacap, Am. Mus. Nat. Hist., N. Y.

I.

In the search for those variations whose accumulated force ushers in new forms in the life series, and by whose influence on the organism as a whole a kinetic impulse is established in a new direction, no more useful field of observation can be chosen than the detailed results of a survey like that of New York. In these volumes devoted to palaeontology we have displayed with laborious care the whole series of species, with their variations and blendings, contrasts and modifications, which the active work of the field, the combined painstaking labors of many students, and the criticism of a final revision have gathered, prepared and published.

A very large amount of the material which formed the basis of these studies ,and a fair number of the type and figured specimens presented in the earlier volumes of the New York survey, and in the Reports of the Regents of the University are today permanently located on the shelves of the exhibition cases of the American Museum of Natural History. The exhaustive catalogue[†] of these alone, now partially prepared by Prof. R. P. Whitfield and Dr. E. O. Hovey, show their extent, while associated with them are numerous specimens, and many large slab groups of species, the whole collection forming, certainly not a complete, but a very instructive view of palaeozoic life. From these, and the published results of the survey the following conclusions have been drawn. It is true that the eye cast over a page of expressive drawings meets more saliently relieved the physical characteristics, size, ornamentation, shape and sculpture of fossil shells and organisms than it does in a line of selected fossils where the number, the surficial dullness and imperfection perhaps fail to produce "at sight" the impression made by luminous and exactingly executed drawings. Still there can be no question that the "original specimen" can never be evaded, and for scientific purposes it is of incomparable value. In a field of general observation, devoid of the extreme precision of "species making," or taxonomic study, both figure and specimen can be usefully studied, and in this paper, conceived as a contribution to evolutional studies, they have been made to supplement each other, the lack of opportunity and material forcing me to rely on drawings perhaps more confidently than I should.

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[*] C. W. Hayes, and M. R. Campbell, locality cited, p 131.

[†] Bulletin, *American Museum Natural History*, vol. xl.

Dr. Sacco in his examination of the Tertiary mollusca of Piedmont[*] has been impressed with those gradations of form. sculpture, color, size, etc., which insensibly merge one species into another, and he deduces some general conclusions, which are of interest in the examination of any group or succession of groups of fossils at any horizon. He finds a species, in a typical condition, has grouped about it more or less aberrant forms, referable, however, to it; he thinks, by reason of priority a variety of species is given the name which should be assigned to the essential form, which through the custom of terminology receives another name. He finds some species mutable and evanescent, others less changeable and dirigible only between certain fixed limits of form; he finds the extremely variable the most vitalized, and they are those which continue for a long series of geological periods, as "their great oscillatory polymorphism around a typical form permits them to adapt themselves to the diverse conditions which succeed each other in the same region, in different geological periods," while more conservative forms disappear or become so fully modified, as to form new and serviceable species. He notes the fact that upon ornamented species the progress of change is most evident, that litoral species are more valuable, less stable than pelagic and abyssal forms, that the varieties of one period develop into the typical species of another, that this development attains a surprising rapidity in some instances, that faunas disappear, and again later, under presumably similar conditions, reappear. Dr. Sacco finds that variations of color are less important than those of form. He dwells, as many other observers, on the internal tendency and external circumstances as constituting the two influences determining change. Amongst the latter are first, biological circumstances, as nutrition, enemies, parasites; second, chemical, as nature of ocean floor, nearness of river mouths, material dissolved in the water; third, physical, as light, conformation of the sea bottom, depth, temperature; fourth, mechanical, water movements.

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[*] Le Variazioni dei Molluschi. DOTT. FEDERICO SACCO; *Bulletino della Societa Malacologica Italiana.* 1893.

His canons of judgment in estimating change, are the addition or diminution of features, and the gradual increase of one feature. He insists on the adequacy of the shells of molluscs to resolve the problems of this development. His especial region of research, the tertiary basin of Piedmont, has furnished him with a most illustrative exemplification of these facts of variation, undisturbed by conditions of immigration, branchings, migration, etc. But he finds himself in carrying on the great work of Bellardi, involved in perplexities of terminology as to the limits and application of the terms subgenera, variety, sub-species, sub-variety, forms, "mutations," etc.

Studies of this nature amongst invertebrates have engaged American palæontologists, and they have especially attracted the attention of Prof. Alpheus Hyatt, Dr. R. T. Jackson, Prof. H. S. Williams, Dr. C. E. Beecher, Prof. J. M. Clarke and Dr. W. H. Dall. At present the examination in its entireness throughout the palæozoics has not reached conclusive dimensions, and every additional contribution, if honestly conceived, cannot be regarded as unwelcome, unnecessary or inopportune.

Prof. H. S. Williams in Bulletins 3 and 80 of the U. S. Geological Survey has discussed the changing facies of faunas, Devonian and Carboniferous, and has indicated how variations have followed slightly changed conditions, and to what extent, in the area considered, groups of associated forms compose characteristic biologic groups that seem to appear and disappear with an exactitude that expresses their identical relations to similar environments. Indeed he says:[*] "the precision with which correlations may be made upon paleontologic evidence is determined by the knowledge possessed of the relations of the elements of organic form to geologic age, so that a fragment of a fossil in the hands of one who knows how to interpret the evidence may furnish a more correct diagnosis of the age of the formation than a bushel of fossils in the hands of one ignorant of the laws of organic life determining the form of the structure produced." He further in this notable essay alludes to the "laws of heredity and evolution," and to the "law of relationship of organisms to each other and to geologic time." And he concludes "comparisons of allied species in the same genus exhibits to him the rate and direction of modification taking place in the genetic history of the genus, and in the plastic or variable characters he finds a sensitive indication of the stage of development attained by the race when the particular individual lived."

A contribution to the genetic relationship of the invertebrate fossils of successive beds of the Tertiary was made in 1885 by Dr. Otto Meyer[†] who endeavored, upon the relevant evidence of evolutional changes, progressive in character, to overturn the recognized succession of the southern Tertiary Eocene. The succession of Claiborne (Middle Eocene), Jackson (Upper Eocene), Vicksburg (Oligocene), which had been defined and established by Hilgard, was inferentially reversed, and the Vicksburg became the oldest, and the Claiborne the youngest stratum. In this particular instance the paleontologist was worsted in an encounter with the less yielding and less suppositititious data of the stratigrapher.[‡] But Dr. Meyer's contribution lost none of its interest, because of a mistaken interpretation, as an index of the application of biological inferences to the questions of stratigraphy; at least Dr. Meyer's genealogical table was in the nature of a remonstrance against wholesale species making, and was a stalwart introduction of the theory of derivation into geological problems.

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[*] Correlation Papers, Devonian and Carboniferous, by HENRY SHALER WILLIAMS; *Bulletin 80 U. S. Geol. Surv.*, p. 263.

[†] *Amer. Journal Sci. and Art.*, vols. xxix. and xxx.; pp. 457, 60, 421.

[‡] See E. W. HILGARD, The Old Tertiary of the Southwest, *Amer. Jour. Sci.*, vol XXX., p. 266.

Dr. Meyer's conclusions were based upon relationships of fauna, as that the lowest Claiborne is more nearly related in faunal features to the Jackson, than is the highest Claiborne, etc.; and upon a study of variations, where it was tacitly assumed that the typical form of a species varied from its first characters progressively in time, giving rise to new species, as the original or ab-original forms disappeared.[*]

Dr. Jackson in his now well known essay on the "Phylogeny of the Pelecypoda"[†] has engaged in the difficult labor of disentangling a line of descent for the Aviculidæ from a hypothetical nuculoid shell and a problematic genus Rhombopteria which he placed in the Lower Silurian and from which through divergent branches of descent incorporating the Devonian genera Actinopteria, Ptychopteria, Pterinopecten, Aviculopecten, Crenipecten, Lyriopecten, Pernopecten (?), he reaches Pecten, Spondylus, Plicatula, Placuanomia, Placuna, Perna, Ostrea, Vulsella Meleagurina, Malleus. This comprehensive examination of a special section was directed to the elucidation of a question of descent, and indicated no generalizations less exclusive than the origin and development of this group of shells.

Also in Jackson's and Jaggar's Studies of *Melonites multiporus*, and in the former's elaborate investigation of the Palaeechinoidea[‡] the biologic processes of development and the morphological scheme of tesselation in the test the field of observation was necessarily restricted. In general treatises such as Gaudry's[¶] *Les Enchainements du Monde Animal,* the speculative conclusions of evolutional relationship are only dwelt upon in the general outlines of animal genealogy.

In any general reference to studies of this nature, Dr. Beecher's essays on the Development of the Brachiopoda, Prof. Hyatt's work on the Phylogeny of the Cephalopoda, and Dr. Hall's "Hinge of Pelecypods and its Development" must be remembered. These are special treatises dealing, with technical precision, with circumscribed questions. They involve great special knowledge and are based upon a careful comparison of observations along a particular line of zoological inquest. But the search for some general tendency, some broad teleological movement of forms, prevailing as a tectonic impulse over or through a diversity of animal groups has not been so extendedly followed. Such a search deals only with primary relations, as size, form, ornamentation, complexity, fecundity.

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[*] A similar mistaken inference with regard to the zoological sequence in the Cambrian faunas, caused, for a long time, as Dr. Walcott has explained, the superposition of the Olenellus beds over those carrying Paradoxides.

[†] *Mem. Boston Soc. Nat. Hist.*, vol. iv., p. 277.

[‡] *Bull. Geol Soc. America,* vol. vii., 1895-6, pp. 135 and 171.

[¶] Les Enchainements du Monde Animal dans les Temps Geologiques: Fossiles Primares.

It deals with more general and simpler questions and it seems reasonable to expect can be answered by an inspection simply of the work of the specialists. For, as Dr. Beecher has said (Origin and Significance of Spines) "the history of a group of animals is the same. The first species are small and unornamented. They increase in size, complexity, and diversity, until the culmination, when most of the spinose forms begin to appear. During the decline, extravagant types are apt to develop, and if the end is not then reached, the group is continued in the small and unspecialized species, which did not partake of the general tendency to spinous growth." An adequate comparison then of the phylogenetic work done in different sections of animal life might reveal general tendencies or laws. It is not difficult to see that it does. In this paper the suggestions are derived from an inspection of the Hall Collection.

SIZE AND SKELETON MASS.

It is evident that in any animal series the primary members are small. It is inconceivable that a group of animals where the members attain any considerable size can on its first appearance in geological time assume complete physical development. An inspection of the Lower Cambrian faunas shows this diminutiveness. With the exception of trilobites the forms are small. The genera *Iphidea, Acrotreta, Linnarssonia, Lingulella, Kutorgina, Obolella, Orthisina, Fordilla,* the patelloids, (*Scenella, Stenotheca*), and the pteropods(?) all express molar immaturity. Organization preceded skeletal deposition.

This fact has considerable interest and appears to contain suggestions of phylogenetic importance. If we find in a fossil fauna well developed skeletons or thickened hard parts (shells, carapace, hinges, etc.), we may conclude that the group represented has attained functional equilibrium, and has existed longer than similar organisms of less physical mass or internal osseous or shelly deposits. The simple and obvious condition prevalent in individuals has an adumbrant genetic application.

While it is unquestioned that favorable conditions, stimuli both of health and food, accelerate the deposition of hard parts, yet it is certainly clear that age brings, of necessity accumulation of material, both because secretion has acted through a longer period of growth, and that in senility the turgor of the secreting membranes so increases as to give rise to heavier depositions of mineral substances (calcification).

And it seems a just inference that at the inception of a group of organisms their physiological relations precede the skeletal sequelæ of these relations, that if hard parts are secreted in the early stages of an organism's history the function of their secretion increases by use, by heredity, through time, and the habit of forming them is reinforced and extended as the organism is geologically older. It is conceivable that the mollusca began in shell-less or almost shell-less organisms,* that the acquisition of shell, the elaboration of hinge teeth and even the interlaminal deposition of "loops," "arms," or internal appendages as mineral or hard parts was slowly, with a slowness sensibly reflected in their palæontological phases, consummated. Or, in other words, the appearance of well developed hard parts internal or external, skeletal or tegumentary, marked an evolutional climax. This is really an ordinary assumption. The biology of the mollusca, and crustaceans, and echinoderms shows the secondary and subsequent development of the hard parts. They are themselves symptomatic of the finished phases of embryological changes. An incomplete power of secretion must have marked the earlier phases of histological growth. In the evolutionary process the heavier armored, thicker shelled, harder carapaced organisms must have followed the more slender fragile and tenuous covered animals.

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*Investigation seems to point to Lingula as a primal form of brachiopodous life. (See Die Silurischen Craniaden der Ostseelands mit Auschluss Gotlands, bei FRIEDRICH BARON HOYNINGEN HUENE. *Verhandlungen der Russisch-Kaiserlichen Mineralogischen Gesselschaft* zu St. Petersburg, 1899). Dr. Beecher has already furnished the evidence to show that the progenitor of the brachiopod phylum was Kutorgina.

Of course this is a general proposition. Selection might rapidly augment the growth of hard parts in some sections of animal life, and comparative immunity from attack or injury, retard or but laboriously develop them in others. There seems no advantage in either size or mass except so far as one or the other, or both, enable an animal to resist destruction or in predatory examples, chase its prey.

The impression, very quickly and keenly felt in examining Cambrian fossils, is that they are small and thin. The trilobites remain conspicuously contrasted with their associated fauna, and suggestions are also evident that the worms may have been large. The morphological impulse which produced large trilobites and worms and left everything else small is not without interesting suggestions, especially as the largest and strongest examples are Middle or Lower Cambrian.

But primarily, is it true that Cambrian life exhibits diminutive and fragile forms? It certainly seems to. There are no large brachiopods, no corals of appreciable size, no large lamellibranchs, no crinoids, few and insignificant univalves. The character of the fauna in these respects is provisional and introductory. The examples of Brachiopoda belong mainly to the inarticulate group wherein functional organization is high, but the later secretatory activities, those which made shells, loops, teeth, etc., which became excited and specialized under new conditions or accidents, were yet dormant. Dr. Walcott, in his "Fauna of the Lower Cambrian or Olenellus Zone," has furnished a review and exposition of what is known of the fauna of this early age. It presents a scattered and broken outline, as from the circumstances was inevitable, of the invertebrate forms of life. It can be, as far as research has gone, neither full nor complete. The forms of life are small and feeble. The trilobites alone, and the worms, present evidences of abundance and development and strength.

In the Hall cabinet *Lingulepis pinniformis, Obolella polita, Lingulella mosia, L. aurora, L. stoneana,* in the western Potsdam are numerous and indicate zones or areas of successful multiplication. In the Troy limestone beds *Lingulepis minima, L antiqua,* and *Obolella prima* seem also plentiful. The trilobites present in the western sandstones the familiar feature of great numbers. The annelidan indications are necessarily suggestive, but in *Scolithus linearis*, *Arenicolites woodi*, the *Myrianites* and *Nereograptus* of Waterville, Kennebec R., Maine, we have plentiful evidence of their wide distribution.

The significance of the trilobites and the striking annelid indications cannot be overlooked. Before passing to these the thought of *Size and Mass*, in connection with development, suggests, with reference to trilobites, an idea of discrimination in regard to age. If the development of exoskeletons, hard parts, hinges and bony or chitinous coverings, is a mark of advanced biogenetic age, then as between two groups of trilobites whose relative antiquity is under discussion that group which presents the greater surface of such members is the younger. Should such a consideration have led *a priori* to the assumption of the greater age of *Olenellus* as compared with *Paradoxides*, because of the marked pygidial enlargements in the latter over the former? For in *Olenellus* the lateral lobes of the pygidium are absent, the axis alone remaining, while slight pygidial wings are incipient in *Paradoxides*. The growth of pygidia is noticeable in the trilobites of the higher Cambrian series, as in Ptychoparia (Conocephalites), Dicellocephalus &c.

In Agnostus and Microdiscus the dual development of head and tail is certainly conspicuous, but their category of growth and relationship is entirely different from the multipleural forms represented in Paradoxides and Olenellus. Olenoides shows also a uniform growth of head and tail. The impression given by a study of these early trilobites is that they were separated in habits of life into two groups, a rapidly moving natatory group like Olenellus, Protypus and Paradoxides with well developed head shields from mechanical reaction against pressure, and a sedentary group in which glabella and pygidium were more evenly related. And that between these extremes Conocoryphe, Ptychoparia, Ellipsocephalus, Agraulos, etc., presented a less determined phase of activity or rest. These considerations, of course, have no reference to their morphological affinities. There is certainly a definable relation between activity and cellular deposition of hard parts. Embryology proves that. The early stages of many sessile organisms, which develop in their maturity hard parts and more or less significant exoskeletons, are marked by great motility and excursive power. Such are the free-swimming larvæ of the Mollusca, the Pluteus of the echinoderms, the Nauplius and Zoea of crustaceans.

At any rate in looking over this phase of fossil forms in the Hall collection the skeletal development of the trilobites is an impressive fact.

If we take the enumeration of species given by Walcott in Bulletin U. S. Geological Survey No. 30, we find the relative percentages of the zoological elements of the Cambrian faunas in North America to be as follows:

Algae	2.30	Brachiopoda	17.04
Spongiae	3.30	Lamellibranchs	.25
Hydrozoa	1.27	Gasteropoda	7.37
Crinoïdea	.76	Pteropoda	5.09
Annelida	1.27	Crustaceans	3.81
Trilobites	57.50		

The number of species in the trilobites more than equals, in its percentage of all (?) tabulated species, that of all the remaining forms of life. And when we consider their numerical proportion in individuals, and examine the blocks of friable sandstone from St. Croix or Trempeleau, Wis., we find they rival in individual enumeration the brachiopods. In short the trilobites in the Cambrian clay clearly suggest *biological preferment.*

In the ninth lecture in Dr. Brooks' series on the Foundations of Zoology wherein the question discussed is natural selection and the antiquity of life, the author places, after the initial stages of zoological development, the scene of the faunal growth on the floor of the ocean. He says, "I shall give reasons for seeing, in the Lower Cambrian, another period of rapid change, when a new factor—the discovery of the bottom of the ocean—began to act in the modification of species, and I shall try to show that, while animal life was abundant long before, the evolution of animals likely to be preserved as fossils took place with comparative rapidity, and that the zoological features of the Lower Cambrian are of such a character as to indicate that it is a decided and unmistakable approximation to the primitive fauna of the bottom, beyond which life was represented only by minute and simple surface animals not likely to be preserved as fossils." Dr. Brooks' assertion that "on the old Cambrian shore the same opportunity to study the embryology and anatomy of pteropods, and the gasteropods and lamellibranchs, of Crustacea and Medusæ, echinoderms, and brachiopods, that he now has at a marine laboratory" seems, if literally interpreted, misleading. Neither is the assumption of a sea bottom, in any abyssal sense, for the Cambrian fauna, at all warranted. The fossils are found for the most part in shore and off-shore deposits. In looking over the Cambrian specimens in the Hall collection Dr. Brooks' speculation, taken in connection with suggestions made by Simroth, (Entstehung der Landthiere), give however a peculiarly fascinating provocation for a supplementary assumption. In a passage of Simroth's of much interest the following observation occurs: "*A priori* the contact of both (land and sea) must form the probable area of the original creation, where both essential factors engaged each other. Therefore the oceanic Bathybius, already discredited by observation, would be found, as source of life, theoretically impossible or at least improbable. And it remains to ask where, in that plane of contact between the atmosphere and the hydrosphere, the most strenuous exchange uninterruptedly occurred, whether on the open sea, or in the coast line. The answer to me appears unqualifiedly to indicate the latter. If we assign, as has been done, to the great waves of the ocean a breathing function, then the surface of the lung passages through whose agency the respiration is effected, must be sought in the tireless movements along the shore, which would be assisted by the foam-masses of the free waves, even if only intermittently aided by stronger breezes. In the high seas, air and water come in contact with one another, but at the beach, water and land, and here the saturation with gas and mineral solutions is equal. But as it is from these opposite elements all interaction issues and depends, then at this position the centers are to be sought from which the organic impulse took its rise, radiating in two directions, seaward and landward."

Such a provisional locus for the inception of life might have resulted, at that moment when the cooling elements had acquired a proper chemical intricacy, for its creation, in a series of protistic bodies such as Pfluger has assumed, unreasonably it seems, existed in one great single concretion. He says, "accordingly I would say that the first proteid to arise was living matter, endowed in all its radicals with the property of vigorously attracting similar constituents, adding them chemically to its molecule, and thus growing *ad infinitum*. According to this idea living proteid does not need to have a constant molecular weight; it is a huge molecule undergoing constant never-ending formation and constant decomposition and probably behaves toward the usual chemical molecules as the same behave towards small meteors."

These protistic bodies,* formed at the margins of the insular masses in the primeval ocean, and beginning the development of derivative forms shoreward and seaward as Simroth suggests, originated two faunal expressions, an annelidean type along shore, a molluscan type in deeper water, and this deeper water fauna shows, at least in its totality, an increase in size and skeletal mass. Do not these Cambrian remains lend support to these curious propositions?

In Europe practically the Cambrian rocks are shore deposits. Their general character has been summarized by Geikie as follows, "the rocks of the Cambrian system present considerable uniformity of lithological character over the globe. They consist of gray and reddish grits or greywackes, quartzites and conglomerates, with shales, slates, phyllites or schists, and sometimes thick masses of limestone. Their false bedding, ripple marks, and suncracks indicate deposit in shallow water and occasional exposure of littoral surfaces to dessication." In America, as is well known, the limestone beds are well marked. At Troy, New York, Rutland, Vt., and in Nevada, Cambrian limestone strata have been described by Ford, Wolff, Foerste, and Walcott. Limestone beds of this age also occur in the St. Lawrence valley, in Newfoundland, in Arizona and Utah.

But these limestone beds though they may be regarded as distinctively belonging to offshore or deep sea sedimentation do not properly express the Cambrian geological facies. They are essentially exceptional, sporadic and ultra-limital. They present an invasion of a sea, and one in which we believe was being formed that more adequate and complete molluscan faunal ex-

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*In a biological sense it is not unreasonable to bring in relation with these the pre-Cambrian radiolarians and sponges found by L. Cayeux (*Bull. Soc. Geol. de France*, 1894; *Am. Soc. Geol. du Nord*, Vol. xxiii, 1895). The sponges found by M. Cayeux were enclosed in phtanytes, and gave evidence of strong marine currents in shallow water.

pression of the Ordovician time. To be sure the fossil remains from these limestones are mainly Cambrian, but apart from the fact that these limestones have not been thoroughly explored their relations to the shore fauna, (properly to be considered Cambrian) as an invasion of the deep sea would have led to the deposit of Cambrian genera and species within them, while their own more characteristic residents, beyond the continental limit, might not have at once followed them inland. The pteropodous species of these limestones are pelagic and might have naturally moved shoreward with the deepening of the Cambrian shore-line. Where indeed their fossil contents are typically Cambrian the limestone seems generally arenaceous or of a shore origin, and in these cases it is not clearly shown that the fossils are as numerous in individuals or species as those of the slates and sandstones, nor whether they represent fossilized individuals *in situ,* or current-transported specimens. In many cases the fossils of the limestone suggest the presence of an articulated brachiopodous fauna, or one of greater *size* and *skeletal mass,* as contrasted with the inarticulates of the Cambrian shallow waters. So in Ford's Troy section *Orthis,* and *Leperditia (Plectambonites)* appear, and in the limestones of the Nevada sections the predominance of *Agnostus** and *Ptychoparia* indicates an Ordovician affinity, while other genera of triolbites *(Protypus, Dicellocephalus, Olenoides)* being glabellate(?) and therefore of relatively more skeletal mass, are later forms than the *Olenellus* or *Paradoxides* and point to an outlying bathymetric fauna.

If this proposition receives further corroboration we are presented with a biological picture of this sort.

Along the Pre-Cambrian coast-waters a process of development or *creation,* ensued from such protistic bodies as may have secured proper elaboration, which resulted in a synthetic type of annelids. From these in divergent directions came the trilobites and the brachiopods, the latter deviating into the heavier shelled genera and families in deeper water, and represented in shallower depths by the ecardines, the former multiplying in swimming forms along the coast with the more carapaced, sessile, and seminatatory forms in deeper water.

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*Agnostus extends into the second fauna and also has a very wide geographical distribution in the primordial rocks. In fact Barande states the single connexion between the primordial and the following faunæ is through Agnostus.

This assumption is hardly violent to those who have watched the tendency of recent biological speculation. Ernst Haeckel in his History of Creation pointed out the archetypal character of the metameral vermes; "the phylum of Worms, on the other hand we have to conceive as a low bush or shrub, out of whose root a mass of independent branches shoot up in different directions. From this densely branched shrub, most of the branches of which are dead, there rise four high stems with many branches. These are the four lofty trees just mentioned as representing the higher phyla—the echinodermes, Articulata, Mollusca, and Vertebrata. These four stems are directly connected with one another at the root only, to-wit, by the common primary group of the Worm tube." In the communication of Prof. J. Beard of the Anatomisches Institut, Freiburg, to *Nature* (Vol. XXXXIX, p. 259) on "Some Annelidan Affinities in Ontogeny of the Vertebrate Nervous System" he remarks that "if we are ever to trace the ancestry of Vertebrates at all, the *nervous system* will probably form a significant factor in the solution." But it is the arthropods which resemble the ringed worms in possessing "a very *characteristic* form of the *central nervous system,* the so-called ventral marrow, which commences in a gullet-ring encircling the mouth." (Haeckel). If the nervous system then is an index of affinity, it serves in the case of the crustaceans to point also to their annelidan origin. Gegenbaur (Comparative Anatomy) shows that. He says "the nervous system of the Arthropoda resembles that of the Annelides with which it completely agrees in its fundamental characters." Simroth says emphatically "so entirely can we see the agreement of the ancient animals in a sum of features that, without further effort to unite them, we demand a common root for their common derivation. What was this? No one can conceive of anything else than an Annelid, and certainly, because of the development of the necessary paropodia for the growth of the articulate members, *of a marine Polychaeta.*"

The pre-Cambrian age was the age of Worms. The rocks of the Cambrian offer evidence of this. The annelidan traces in the Potsdam slates and sandstones, shales and flags exceed those of any similar beds throughout the palaeozoics.

Scolithus is prevalent in Potsdam layers, the ch
of the Kenebec river, Maine, are thickly covered wi
of worms (Chaetopods?), Arenicolites, as determin
field, fills broad spaces of the Barriboo beds in Wiscon
orst has indicated the numerous traces of annelidan tracks in Scandinavian Cambrian. Climactichnites and Protichni
may all be the reptant impression of large broad ringed worms.

It seems impossible to reject the patent suggestions of biology which are thus partially reinforced by the indeterminate but significant instances of fossil traces.

In considering further the hypothetical picture of primordial zoic tendencies the con n seems obvious that in shallow water forms—the trilobite d ecardines—we have chitinous integuments, in the deep water calcareous, mainly presented. This seems connected wit histological peculiarities which no refinement of c al biology can yet completely touch. The contrasting separative features between a shore and a deep-water ex ice are of course primarily the longer exposure to light, a a greater likelihood of mechanical violence, on the later removal from these vicissitudes and subjection to pressure with a richer supply of dissolved mineral materials.

Simroth in his interesting section "Einfluss der Atmosphare auf das Integument," has offered some instructive parallelisms, symptomatic, in the case of the shore animals, of the stages in their assumption of hard coverings. The hardening of the epidermis by exposure to air and light led he thinks to the gradual replacement of the hairy surfaces of the worms by soft chitinous coats, which grew stronger and thicker as the metamorphosis went on and the changes to such a triplicate exoskeleton, as the arthropods possess, were completed.

The Brachiopoda have been clearly considered referable to the annelids. Prof. Sedgwick believes "we must assign to the group the position of an independent phylum of the animal kingdom with affinities, by the form of their central nervous system and by their setae, by the presence of a well-developed perivisceral coelom and a canalicular haemocoel, and by the traces of an imperfect segmentation, to the *Annelida.*" We find therefore the phosphatic thin shelled atrematous Brachiopoda and the chitinous covered trilobites well represented along the Cambrian beach line, and we are led to accept for them an annelidan origin. It is, as we pass upward geologically in the inspection of these classified fossils of the Hall collection that we meet, in the deeper seas of the Calciferous group, a development of *size and skeletal mass* in the heavy shelled brachiopods, gasteropods and cephalopods.

If the acquirement of hard parts by the shore fauna was due to the siccative influences of their position, their response to light stimuli, and their gradual assumption of protective coats against the violence of waves, the more robust and calcareous groups which succeed them may be related to water pressure and the bountiful supplies of dissolved mineral elements in the deeper seas. I do not know where to turn for evidence on this point. Barotaxis has been by Verworn distinctly indicated as a physiological agent. "Every degree of pressure can act as a stimulus, from crushing or cutting, which destroys the continuity of the substance, down to the slightest touch and the most delicate change in the pressure of the air or the water that surrounds the organism."

Now it is an accountable supposition that this pressure of water originally exercised a stimulating influence upon organisms prepared to secrete shelly coverings, and that while on the one hand the crustacean forms and inarticulate brachiopods in their evolution from annelidan ancestors along the shores, developed their thin chitinous and phosphatic tissues, the molluscan and coelenterate life in the deeper waters was forcing its energies into the manifold elaboration of calcareous coats and skeletons.

Dr. Dall in his address at the anniversary of the Biological Society of Washington on Deep Sea Mollusks indicated the conditions prevalent at the sea bottom. The great hydrostatic pressure, the presence of carbonic acid, sub-marine currents both acting as mechanical sweepers and food-carriers, darkness, the absence of vegetation, and a recourse for nourishment to Foraminifera and the rain of pelagic organisms from the surface are therein mentioned. But perhaps as bearing on this question of the sudden evolution of the next fauna above the Cambrian, and which it is intended here to regard as of deep sea origin, are his reflections on the absence of conflict in the abyssal or archibenthal (semi-abyssal) regions. He said "the animals belonging to the Mollusca which are found in the archibenthal and abyssal regions, especially the latter, do not live in a perpetual state of conflict with one another. A certain amount of contention and destruction doubtless goes on, but on the whole the struggle for existence is against the peculiarities of the environment and not between the individual mollusks of the area concerned. It is an industrial community, feeding, propagating and dying in the persons of its members and not a scene of carnage where the strong preys upon his molluscan brother who may chance to be weaker. Hence the course of evolution and modification, though still complex, is certainly much less so than in th shallower parts of the ocean." Now in the early seas there were probably no depths comparable with the abyssal spaces of modern oceans. The fauna which arose and may have been partially contemporaneous with the Cambrian and which as a stratigraphic fact we find overlying the latter, was evolved in an offshore, and not necessarily profound basin. If freedom from competition and from destructive foes is true today in deep sea animals it was, especially as fishes were absent, more markedly true of these primal groups, and this may have produced that uniformity, a general evenness and similarity of shell-life, without strong or salient variations, which certainly is apparent in the Cambro-Silurian beds of fossils.

At any rate it is certain that passing into the next section of the Hall fossils we encounter the evidences of a new fauna, one especially emphasized by the discoveries in Vermont of Profs. Brainerd and Seely. It is a limestone fauna, a deep sea fauna, and its development upon a scale of such magnitude with such diversity of fauna, with such a systematic zoological overthrust upon all Cambrian precedents, leads clearly to the conclusion that its growth extended far back in time and brought it, at its inception, into contemporaneity with the shore fauna of the Cambrian formations. Size and skeletal mass are now very obvious in molluscan life.

Conditions of life were probably identical with those of today so far as the propagation and maintenance of genera and species were concerned, and, as today extreme deep sea (abyssal) areas are inimical to animal abundance, the faunas, succeeding the Cambrian, if formed in deep water, may have moved shoreward upon a deepening of their former habitat when crustal shortening or the slow folding of synclinal troughs, from sedimentation, occurred.

While it seems naturally a fair speculation that the influence of pressure would have upon developing molluscan organisms the effect of hastening their secretive functions, and that such influence might have been the original cause of establishing the shell forming habits of molluscan animals, we may further consider the thermal conditions of deep water in those early days. It must have presented sensibly high thermal phases, and, to quote Verworn, "everywhere in living nature the law is met with, that within certain limits increasing temperature acts to augment vital processes."

This increase in temperature in the first days of oceanic life arose from the convexion of heat radiated from the cooling continental masses. The raising of lithic masses by contraction must have imparted heat to the seas while indeed their bottom waters rested upon the cooled surfaces of an original cosmic fireball. It was such thermal conditions that directly contributed to an increase in the mineral constituents of the sea water, and might have in this way also hastened the development of shelly parts in sea animals.

The Calciferous sandstone as revealed by Hall was a siliceous shore deposit, and only the records made in the Champlain (Seely and Brainerd) basin display its unequivocal bathic features. The fossil remains present a cephalopodous and gasteropodous fauna. Brachiopods of sensible dimensions and representing the articulate phylum appear, and we find that with the exception of corals and crinoids the palaeozoic biologic impulse has reached molar expression. The initial stages have been far passed. The divergences in genera and classes are thoroughly established. The partial introductory phase of the Cambrian day with its eccentric development of trilobitic forms and its thin shelled brachiopods has been succeeded by a multivarious and expounding series of organisms heavily armored in calcareous coverings.

From this point onward throughout the palaeozoic series the application of the significance of *Size and Skeletal Mass* is generally evident. Let us consider the separate fossil groups. The inarticulate brachiopods present noticeably larger forms, and in the Upper Silurian develop into the large and internally elaborated Trimerellidae.

The size and skeletal mass of the inarticulate brachiopods reached its maximum in the Upper Silurian. The articulate brachiopods show increasing size, and increasing internal shelly deposits (loops, hinges, cardinal areas, etc.,) from the Cambro-Silurian upward. The Rhynchonellidæ, Orthidæ, Strophomenidae gradually yielded their numerical supremacy, while advancing themselves greatly in size. They become diminished elements in the fauna of the upper rocks, as they become more numerously accompanied by the spiriferoids which attain large dimensions in the Devonian and Carboniferous and exemplify the extension of interior calcareous appendages and hinge growth. In the Carboniferous (lower) the families of Orthidae and Stropheodontidae also attain large size. The lamellibranchs increased in size continuously to the Devonian, and through the latter age became conspicuously developed. The gasteropods attained large proportions in the Devonian. The cephalopods were, in the straight forms, strongly developed quite early in the series and through the coiled genera continued their growth and accretion to the Jurassic, while in modern seas they have attained huge proportions, but without shelly coverings.

The crinoids were slender, small calyxed, long armed, in the Lower Silurian, and through manifold divergences, with sporadic and sudden offshoots reached the thick, heavily plated, short armed, stout pedicelled groups of the Devonian and Carboniferous.

When the separate genera or families are examined this progression of size and skeletal mass to certain maximum points, followed by an apparent decrescence immediately or subsequently introduced, is very striking. Its theoretical interest lies in the impossibility of referring this universal tendency in molar character to natural selection, or any series of influences purely external to the organism.

The considerations which warrant this conclusion are not so much drawn from particular instances as from the general tendency throughout these animal fossil forms. That size, stronger, larger shells, internal shelly partitions, surfaces of attachment, hinge definition and interior branchial elaborations might prove of material value in Mollusca, and through the aggregate effect of stability, power of resistance, and mechanical aptitude help any genius, enjoying these features, in the struggle of survival, and so lead to new and more advanced developments of the same elements, is quite possible, but it is clear that the fact of this development of size, skeletal mass, etc., throughout the organic impulse in the past, is more profoundly conditioned.

In the first place the perpetuity of slight, small forms is quite as great as that of larger forms. The Lingula has outlasted a wide range of heavier and more imposing brachiopods, and the unprotected cephalopods survive the marvellous "straight horns" and ammonites of ancient seas. The frail crinoids of our present ocean bottoms continue a line of descent quite contrasted with the well plated, high calyxed, tegmenated, and massive species of palaeozoic time. Gasteropods and lamellibranchs have continuously enlarged up to present times, but the mere aspect of size, thickened shells and involved hinges seems in their case also utterly incomprehensible on the supposition of a survival. All the more so as along with the increase there continues a stream of small forms. It shows a distant biogenetic tendency. Even if natural selection finds in increase of size and molar complexity a field of advantageous activity the continuous expression of these things reveals an implanted, not a succedaneous, motion in life, and, partially at least, illustrates Prof. Osborn's dictum (Cartwright Lectures, 1892,) "that evolution advances largely by the accumulation of definite variations, or those in which each successive generation exhibits the same tendencies to depart from the typical ancestral forms in certain parts of the body, and that these tendencies stand out in relief among the diffused kaleidoscopic or fortuitous anomalies."

It remains for the conclusion of this *first* part of the present paper to demonstrate the fact of the growth in size and skeletal mass of the invertebrate forms of palaeozoic fossils. It is true that there is no consecutive line of symmetrical growth traceable upward with uninterrupted precision to a climax, with a subsequent regular decrescence. It is also true that along with growth in size and solidity and skeletal thickenings and irregularities small primitive forms survive and new ones equally small appear. It is true that there are alterations and waves of advance and retreat, that a group of strongly developed organisms may be followed by less developed examples of the same groups. But looked at broadly and carrying the eye forward rapidly the impression is unmistakable that there is a tendency to molar expansion, skeletal growth, and that from some maximum point there may be recession and that both seem essentially independent of environment, and are inexplicable on the assumption of the "Survival of the Fittest."

To begin with the linguloid and obelloid shells can be traced upward to Trimerella through a series of increasing size and changing internal hard parts or shell buttresses, while nowhere do large sized individuals signalize the first appearance of a family. Dr. Clarke in the first particular instance offers convincing evidence. He points out (Pal. Vol. VIII., Geol. Surv., N. Y.) that a line of succession from a linguloid shell through two divergent lines can be traced to the large heavy Trimerellas with internal platform, prominent cardinal areas, solid and lengthened umbo. One line is through *Lingulella, Lingula, Lingulops, Lingulasma,* the second through *Obolella, Obolus, Elkania Dinobolus.* Whether this is a true genealogical series or not it is a very clear proof of assumption of size and skeletal mass through successive formations, of a group of ecardines, though *Lingulops* is a small shell, and serves the purpose only of advancing internal structure. *Lingulasma,* on the other hand, is a quadrate strong and well developed shell, and, as Dr. Clarke shows, is "to be regarded, in unison with other features, as evidence of progress in the assumption of the characters of the large thick-shelled Trimerellids." In the other hypothetical succession *Obolella* is a small sub-circular shell with an area; *Obolus* is a large shell, *Elkania* is a doubtful link and a small shell, *Dinobolus* is a large platform-bearing shell and in the American Niagara (*D. Conradi*) presents approximative features to *Trimerella.*

Again *Lingulepis* is a primordial linguloid shell, and is limited in its distribution to Cambrian beds, but increase of size is symptomatic even within these limits. The *L. minima* and *L. antiqua* of the N. Y. Potsdam are small, the former an inconspicuous shell, whereas *L. pinniformis,* the western form

(Minnesota). is a much larger, stronger and thicker shell, and the beds at St. Croix, where it is so numerous, are considered later or Upper Cambrian, indeed, might be so considered upon this evidence alone.

Obolella is a primordial genus, but the evidence of increased size, with geological age is not at all clear. The N. Y. species, *O. crassa,* is much larger than *O. polita* of Wisconsin, but if *Lingula prima* Conrad, is Hall's *O. polita,* as Prof. Whitfield claims, the argument still holds as the western form in this exact instance is much larger than its eastern and earlier representative.

Turning to *Discina* and *Crania* we find this general proposition still obviously sustained. If under *Discina,* so far as the elements of this inquiry go, we group the discinoid shells *Discinisca, Orbiculoidea, Schizotreta, Lindstroemella, Roemerella,* we find the increase of size well shown. The small *Orbiculoideas* of the L. Silurian becomes the large *O randalli* and *grandis* of the Devonian.

Lingulas increase in their dimensions from their first appearance, and it is the acuminate type which prevailed in the earliest faunas (Clarke) which is succeeded by the broader, more developed forms, while, as indicated by Clarke, *Barroisella,* with its deltidial hardenings, coming in in the Devonian, continues the Lingula type until there is "an evident tendency to span the interval between the so-called inarticulates and articulates."

Trematis, as confined apparently to American Silurian faunas, shows a sensible increase in size and general development, if *terminalis* of the Trenton is compared with *millepunctata* of the Hudson River group.

In the articulate brachiopods this same organic impulse is distinctly presented. In the feature of increasing articulation Dr. Clarke has said, "with rare exception these modifications in each group appear to be progressive, extending along certain lines of development, and finally acquiring an extravagant manifestation which may terminate abruptly or result in the degeneration and obsolescence of some of the parts."

The spiriferoids reach a climax of development in the Devonian and Carboniferous. The increased size and the amplified cardinal and hinge features reaching such complexity as is shown in *Syringothyris*, contrast with the incipient stages of growth and structure in the spirifers of the Silurian.

The strophomenoids from the leptænoid *(Rafinesquina)* shells of the Silurian show a constant enlargement with varying offshoots or auxiliary branches, to the huge Productus and Stropheodontas of the Devonian and Carboniferous.

The first pentameroid shells are small and the later species of the Upper Silurian attain magnificent proportions with increased internal calcifications.

As the heterogeneous commixture of forms originally placed under *Orthis* have undergone at Dr. Clarke's hands a thorough revision and reassortment, their continuity from formation to formation is considerably broken, and many of the new genera are restricted to single formations. But in *Platystrophia (Orthis biforata, O. lynx)* there is from the Chazy to the Clinton and Niagara, and especially prominent in the Cincinnati beds (Hudson River) the same obvious increase in size. *Dalmanella testudinaria* of the Trenton strengthens into *perelegans* of the Low. Helderberg, *Rhipidomella circulus* of the Clinton into *R. burlingtonensis* of the Carboniferous, *Schizophoria multistriata* of the Lower Helderberg. The atrypoid *Zygospira* becomes later enlarged into the true Atrypas, which themselves in the same species (*A. reticularis*) persistently increase in size (see Clarke's observations, Pal. N. Y., Vol. VIII., pt. II., pp. 167-172). It is unnecessary to pursue a self-evident contention further.

Wachsmuth and Springer have expressed (North American Crinoidea) in crinoids their unwillingness to construct a genealogical tree, "because such representations are generally unsatisfactory." But in this very general proposition the evidence of an inspection of the species from the Silurian to the Carboniferous shows conclusively that size and skeletal mass increased, and that whether or not "palaeozoic crinoids represent, in a broad sense, the larval stages of recent crinoids," the movement in massiveness from the Silurian to the Carboniferous is, amongst them, evident. The large heavily plated *Eucalyptocrinus* of the Niagara was a sporadic (Calyptocrinidae) and short lived development, but it would be an insupportable hypothesis that *Eucalyptocrinus* was an unannounced development.

The cephalopods of the Cambro-Silurian were small. *Orthoceras (Kionoceras) laqueatum, O. sordium, O. cornu-oryx, O. bilineatum, O. explorator* of the Chazy or Calciferous, and the species determined by Dwight, those of Billings' Palaeozoic fossils and Hall's examples were nearly all narrow, short species. In the Trenton the large Orthocerata appear. Similarly the Lower Silurian *Cyrtoceras, Gomphoceras, Phragmoceras* precede the Niagara forms sensibly heavier and more developed.

The trilobites which were large in the Cambrian, and thin skinned (?), become in later ages more calcified, heavier carapaced, with enlarged pygidia.

Variant, as at some points this conclusion may seem, the conclusion of growth in size and increased functions of mineral secretion is almost invariably forced upon us from an inspection of the fossil lines of growth. It utterly dispenses with any claim of novelty. But it seems as if it might be more generally recognized as a guide in the correlation of the horizons, geographically separated and characterized by the same fossil species. If we find a faunal expression in forms strongly developed, with larger fossils, and associated with increased skeletal deposition of parts, it is a reasonable conclusion that, apart from any or all considerations of improved food supply, climatic auspices, or freedom from enemies, the horizon is subsequent to those in other sections, possibly holding the same species, in which these fossils are less developed, generally smaller and unassociated with morphological complexity.

Questions of correlation are deservedly regarded as involving a momentous risk, in so far as dogmatic assertion goes, and the hope entertained to find in biological relations a definite guide has been realized only within indeterminate limits. Huxley's well accepted idea of "homotaxis" shows the unreasonableness of any exact inference as to simultaneity of faunas where there are the same fossil species, and writers on correlation have recognized the precarious virtue of an appeal solely to identity or similarity of specific forms.

Russell (Correlation Papers: The Newark System) has said, "the usefulness of the life history of the earth as a means of correlating geological terranes is still further complicated by a principle inherent in life itself: that is, development has been in progress, but has not taken place uniformly over the whole earth, but with local modifications depending upon local environment." White (Correlation Papers, Cretaceous) reiterates this in stating that "general biological evolution, while it has been progressive, has not progressed at a uniform rate throughout geological time, and in all parts of the world."

A less conservative and, it would seem, more reasonable reliance upon fossil indications is expressed by Walcott, Williams, Dall and Harris. Walcott says: "The method of correlation by the comparison of fossils, or, as it has been called, 'matching,' is the one that affords the best results. It includes the comparison of species, genera, families, and the general facies of a fauna.... It is the basis of paleontologic correlation and geologic classification of the sedimentary rocks, with the exception of the stratigraphic and lithologic correlation of local formations." "All paleontologic reasoning is based upon known data. By the discovery of a new grouping of fossils or a different range of known species, the identification of horizons may be materially modified." Dall and Harris write: "Paleontology holds the key to the problems of local and comparative stratigraphy," admitting also that there should be no neglect of "broad and general stratigraphic changes." Williams writes: "The law of paleontologic succession did not become a factor of correlation till the idea of the evolution of species furnished a rational basis [illegible] confidence [illegible] the natur- ness of the observ[illegible] of evolution suggests [illegible] in which [illegible] tinctions [illegible] the strata bearing their [illegible] to the [illegible] mains [illegible]

The value [illegible] tion cannot be [illegible] knowledge [illegible] the same or very similar fossils [illegible] disparity is dismissed [illegible] parity can be neglected [illegible] ter of geological [illegible]

Whether [illegible]

one here suggested can be advantageously or safely adopted is a matter for discussion. Are the molar, or, it might be termed, the molecular features of a fauna indication of comparative age? In any case it would be merely an auxiliary consideration. It might be easily misapplied and warrants in itself no ultimate decision. But is it not helpful?

Is it reasonable upon this suggestion to place the Spergen Hill beds, which, as Whitfield has said, "contain an intermingling of species known to occur in the Keokuk, St. Louis, and Chester limestones," below any of these from the immature condition of size and development of these fossils? By no means. The whole expression of the Spergen Hill fossils, as found in the limestone beds is one of repression. These depauperate forms have resulted apparently from a peculiar fecundity, or tidal concentration,which has, under some unfavorable conditions, produced a great number of interfering individuals. At Poynter's Hill and at Ellettsville, at no great distance from Spegen Hill, these same beds, with fewer fossils, show larger individuals.

But, on the other hand, it would seem reasonable to conclude that the western Hudson River, which as Hall long ago observed, contains a fauna of brachiopods, with corals, crinoids, Crustacea and trilobites, and in the same species far more developed than the fossils of its eastern equivalents, was later than the New York beds of the same age.

(To be Continued.)

THE PLAN OF THE EARTH AND ITS CAUSES*

By J. W. Gregory, D.Sc., Melbourne, Aus.

The Variation of Topographic Form.

Despite the extreme variability in the shapes of the continents and their apparently capricious distribution, geographers of all ages have believed that the arrangement of land and water on the globe is based on a regular plan. The plan can, of course, only be recognized in broad outline, for the shape of the land-masses depends on the structure of the Earth-forms, which vary indefinitely. Intricate mountain valley

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*From '*The Geographical Journal*' for March.

systems open out to wide-flung rolling prairie, stoneless alluvial flats are broken by the crags of rock ridges, volcanic cones stand isolated like pyramids while mountain chains run thousands of miles unbroken. Such contrasts are natural, as the land-forms are the result of the struggle of complex forces with varying powers of attack against complex rock-masses formed of materials having varying powers of resistance. Coast-lines, for example, project where hard rocks repel the surf, where rivers deposit alluvium more quickly than the tide can remove it, or where the winds build up sand-dunes, whose very weakness disarms the waves. Coast-lines are indented where soft beds crumble under frost and rain, and where dominant winds, the inset of an ocean current, or an undulation on the sea floor directs a jet-like stream of water against the shore. Topographical form depends on so many incalculable, inconsistent factors that the stages of its growth are often now untraceable. The missing links of geographical evolution are indeed as numerous as those of organic evolution, and the chapter of accidents is invoked by geographers to explain difficulties analogous to those for which naturalists appealed to the doctrine of special creation. But unexplained differences in the geographical units no more disprove an orderly progress in the growth of the continents than the existence of isolated, unexplained groups of animals is fatal to Darwinism. Such topographical differences are of secondary importance in contrast to the numerous coincidences and repetitions of the same essential form among the geographical units. Geographers accordingly have believed that there is a hidden continental symmetry which, when discovered, will explain the law that has determined the distribution of land and water on the globe.

This idea dates from the dawn of geographical science. The early classical geographers noticed how the seas radiated from the Levantine area, and opened to a broad boundless ocean. They accordingly described the land of the globe as an island, floating on a vast surrounding sea, whence channels converged towards the hub of the classical universe. This radial plan reappears in the mediæval wheel-maps, in which Jerusalem was accepted as the center of the world, whence the main geographical lines radiated like the spokes of a wheel.

These systems fell forever on the discovery of America, which could not be brought into conformity with the radial plan by even the ingenious devices of mediæval cartographers. Later on came an even worse blow. Geologists showed that, instead of the land areas being fixed and immutable, they are really more fickle and less enduring than the sea. The distribution of land is therefore constantly changing, owing to local variations in its level. The discovery of this truth seemed to destroy the very basis of any possible Earth-plan. Indeed, Lyellism, with its essential doctrine of the alternate elevation and subsidence of the land under the agency of local causes, seemed inconsistent with the existence of any general cause governing the geographical evolution of the globe as a whole.

But a truer appreciation of this later knowledge did not confirm these first deductions. America is now used as the typical or, to borrow a biological phrase, the schematic continent. And when, remembering the probability of local variations in land-level, allowance is made for them, new resemblances are revealed, and exceptions that once were serious difficulties are removed. For instance, the oceans all end in triangles pointing to the north. This is the case with the Pacific, the two sections of the Indian ocean, and the basins of the Mediterranean. The Atlantic alone is broadly open at its northern end. But Scotland and Iceland are connected by a submerged ridge, which is said to be capped by a line of old moraine. If this ridge were raised to sea-level, the Atlantic would conform to the general rule by tapering northward to a point between Iceland and Greenland.

Similarly with the land-masses. There seems at first sight no resemblance in shape between the Old World and the New. But the Old World is divided into halves by a band of lowland, which extends southward from the Arctic ocean to the Caspian, and northward from the Arabian sea up the Persian gulf. There is evidence to show that the sea recently covered these northern lowlands and occupied the Persian depression; while somewhat earlier, in the Miocene times, the intervening ridge was also submerged. Restore these conditions, and the continents would occur as three meridional belts, each broken across by transverse Mediterranean seas, viz. North and South America separated by the Caribbean depression; Europe and Africa (the Eurafrica of Prof. Lapworth) separated by the Mediterranean; Asia and Australasia divided by the Malaysian folds.

Hence the oscillating character of the land, which appeared fatal to the old faith in an Earth-plan, helps to justify it, now that oceanography and geology have shown us how much to allow for the obscuring action of these changes of level.

But it is inadvisable, in attempting to explain the existing plan of the Earth, to introduce any alterations in the distribution of land and water. For, although a geologist may have no doubt about such assumed changes, he cannot expect geographers to have an equal faith in them, or even to take much interest in a world thus modified. The geographer is concerned with the existing arrangement of the world, and not with the more or less problematical plans of former ages. The introduction of earlier and more primitive geographical systems, though it would simplify the question, is unnecessary, since the existence of a present Earth-plan is clearly revealed by three striking facts.

GEOGRAPHICAL SYMMETRY.

Two of these facts are stated in every geographical textbook. They are evident on the most casual examination of a map. The first is the concentration of land in the northern, and of sea in the southern hemisphere. The second is the triangular shape of the geographical units. The continents are triangular, with the bases to the north. The oceans are triangular with the bases to the south. Accordingly the land forms an almost complete ring round the north pole, and from this land-ring three continents project southwards. The oceans form a continuous ring round the south pole, and from it three oceans project northward into the angles between the continents. The belts of sea and land are fixed on the Earth's axis like a pair of cog-wheels with interlocking teeth. These two belts may be referred to as the northern land-belt and southern oceanic-belt.

The third striking feature in the Earth's physiognomy is less conspicuous, but is even more significant. It is known as the antipodal arrangement of oceans and continents. It is most easily recognized by examination of a globe; but it can easily be illustrated by a plain map. The antipodes of a point in the center of the continent of North America occurs in the Indian ocean; and if we mark on a map the antipodes of all the points in North America, we should find that the whole of that continent is exactly antipodal to the Indian ocean. Similarly, the elliptical mass of Europe and Africa is antipodal to the central area of the Pacific ocean; the comparatively small continent Australia is antipodal to the comparatively small basin of the North Atlantic; the South Atlantic corresponds—though less exactly—to the eastern half of Asia; and the Arctic ocean is precisely antipodal to the Antarctic land.

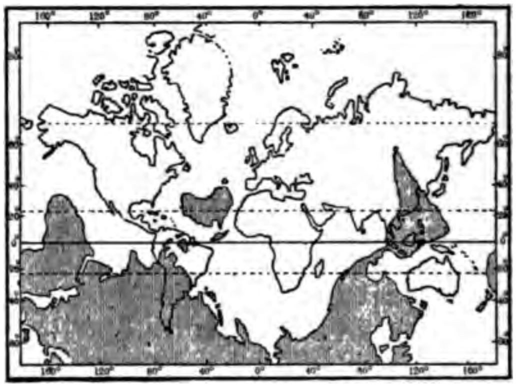

FIG. 1.—MAP OF THE WORLD, SHOWING THE DISTRIBUTION OF ANTIPODAL AREAS.

These, then, are the three fundamental facts in the existing plan of the globe. Our main problem is, Why are the geographical elements thus shaped and thus distributed?

THE EARTH'S CONCENTRIC SHELLS.

It simplifies the statement of the problem to remember that the Earth consists of three parts: there is the vast unknown interior, or "centrosphere," concerning which physicists have not come to any unanimous decision, some saying that it is throughout solid and rigid, others that it is partly fluid, and others again that it is partly gaseous. This interior mass is enclosed by a shell formed of two layers, the solid crust, or "lithosphere," and the oceanic layer, or "hydrosphere." It is possible that at first the two layers of the shell were regular and uniform, in which case the whole world was covered by a universal ocean; but before the dawn of geological history, this arrangement had been disturbed by the formation of irregularities in the surface of the lithosphere. Dry land appeared at the areas of elevation, and the waters gathered together into the intervening depressions.

The problem, then, of the distribution of land and water on the globe is the problem of the distribution of irregularities in the surface of the lithosphere. We are accordingly at once brought face to face with the question, When were the existing irregularities made? If, as many authorities say, these depressions date from the earliest days of the Earth's history, and have lasted unchanged in position throughout geological time, then we are thrown back upon some cause which acted when the Earth was in its infancy. In that case the question is astronomical and physical, instead of geological and geographical.

PRE-GEOLOGICAL GEOGRAPHY.

There have been several attempts to solve the question astronomically, of which the most important is that of Prof. G. H. Darwin. According to his luminous theory, the tidal action of the sun on the viscous earth formed two protuberances at opposite points of the equator; one of the protuberances broke away and solidified as the moon, which revolved around the earth much nearer than at present. As a new equatorial protuberance formed the moon pulled it backward, thus causing a series of wrinkles in the earths' crust, which persist as the main structural lines of the continents. These wrinkles ran at first north and south from the equator. But owing to the moon's strong pull on the equatorial girdle, this part of the earth would tend to revolve more slowly than the polar regions. Hence the primitive wrinkles were deformed; instead of being meridional in direction, they would trend northeasterly in the northern hemisphere, and southeasterly in the southern hemisphere. Prof. Darwin points out that some of the most striking geographical lines on the earth run in accordance with this plan. He instances the eastern coast of North America, the western coast of Europe, part of the coast of China, and the southern part of South America. But, with characteristically Darwinian frankness, he does not overpress the facts, admits that the resemblances are not so convincing as they might be, and that some cases, *e. g.* the western coast of North America, are absolutely inconsistent with the scheme.

Another theory that attributes the formation of the main geographical lines to pre-geological incidents is given in a paper by Prinz, "Sur les similitudes que presentent les cartes terrestes et Planetaires," which elaborates and gives an astronomical basis to ideas previously suggested by Lowthian Green and Daubree. His theory is that the northern part of the earth had a lower angular velocity than the equatorial and southern regions. Therefore the land masses in the southern hemisphere were gradually pushed forward towards the east. The line between the northern retarded hemisphere and the southern swifter hemisphere is the great line of weakness and fracture that runs from the Caribbean along the Mediterranean, down the Persian gulf and across Malayasia. Prinz has drawn a map (Fig. 2) showing how the main geographical lines agree with his assumed lines of torsion.

This map is interesting, for these primitve torsion wrinkles must have been formed in the same period as Prof. Darwin's primitive tidal wrinkles. It is significant that the lines do not correspond. The chief geographical lines which Darwin claims as his primitive wrinkles are inexplicable on Prinz's theory, and the great lines which Prinz claims to support his wrinkling are opposed to those of Darwin. The geographical primitive lines of the two theories are often contradictory.

A third theory assigning the geographical distribution to very ancient causes has been proposed by Prof. Lapworth. In an address to the geographical section of the British Association in 1892, and in a brilliant lecture on "The Face of the Earth," delivered to the Royal Geographical Society in 1894, Lapworth attributed the arrangement of oceans and continents to an intercrossing series of primitive earth-folds. The oceans, according to this theory, occupy ancient basins of depression; and the continental masses are domes of elevation.

"The surface of the earth-crust at the present day," says Lapworth, "is most simply regarded as the surface of a continuous sheet which has been warped up by two sets of undulations crossing each other at right angles. . . . The one set ranges parallel with the equator, and the other ranges from pole to pole." Prof. Lapworth contends that the intersecting of two simultaneous orthogonal sets of undulations explains the forms and dispositions of the continents, the triangular shapes of their extremities, the diagonal trend of their shores, and the course of the linear archipelagoes. In some interesting diagrams he suggests why the intersecting nodal lines which mark the divisions between the areas of elevation and of depression should coincide with the steep slopes that separate the ocean floors and the continental platforms; and why the existing shore lines should so often run diagonally between the meridians and parallels.

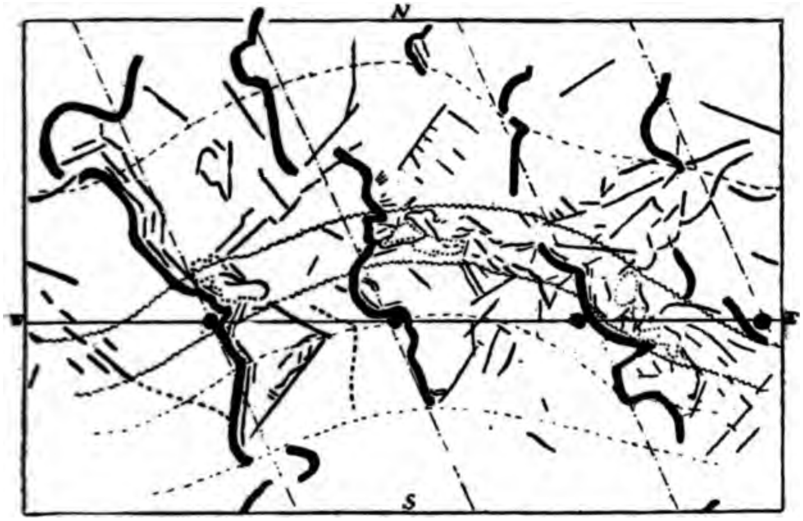

FIG. 2.—THE OBLIQUE COURSE OF THE MAIN GEOGRAPHICAL LINES. (AFTER PRINZ.)

This theory, and that of Sir John Lubbock, which also attributes the continental forms to a double intercrossing series of folds, have the advantage over the astronomical theories of more detailed agreement with geographical facts; but Prof. Lapworth has not, so far as I am aware, explained what caused his intersecting folds. His theory is accordingly less complete than the others, as it is rather a statement of facts than an explanation of causes.

These suggestive theories are open to one objection which seems fatal to their application to the existing geographical plan. We should expect from them that the main geographical structure lines in the northern and southern hemispheres should be either symmetrically arranged or continuous on both sides of the equator. But that the land systems of the two hemispheres are asymmetrical is the most glaring fact in geography. It may be urged that the primitive folding, wrinkling and torsion formed a symmetrical or continuous land system, and that the asymmetrical arrangement is due to later movements. In that case the theories are geographically inadequate, because they give no explanation of how the existing geographical asymmetry was developed.

But there is another and still more serious objection which applies to all three theories. They not only explain too little but they explain too much. The primitive lines of these systems often coincide with features of modern development and are inconsistent with the old established geographical arrangements. For instance, Prof. Darwin quotes the trend of the western coast of Europe from Spain to Norway as in accordance with his scheme. Prinz makes the primitive line here run exactly at right angles to Darwin's line; and geological evidence favors Prinz. The coast-line from Spain to Norway is almost certainly of modern date, while the lines wrinkling, both Hercynian and Alpine, run transversely to the direction which they ought to have followed if due to tidal strain. Moreover, Prof. Darwin quotes the western coast of North America as inconsistent with his theory; but that coast is parallel to a line of primitive wrinkling, for there is an archean protaxis to the coast ranges and Rocky mountains.

Prinz's torsion wrinkles are no better. The most striking case of apparent agreement between his theory and geography is the trend of the Andes and Rocky mountains. Prof. Lapworth also lays stress on "the great Rocky Mountain-Andes fold . . . the longest and most continuous crust-fold of the present day."* The agreement was important so long as the Rocky mountains and the Andes were regarded as a single mountain system, connected into a continuous line by a mountain axis running north and south across Central America. But that axial mountain chain in Central America is a myth. Central America is traversed by a series of ridges which run east and west, and not north and south.* The watershed, it is true, runs along the Pacific border, but that is due to a movement later than the mountain ridges which are thus truncated. The continuation of the Andes is in the mountains of Venezuela, not in North America or the Sierra Nevada. The Andes and the mountain system of the western states of America are essentially distinct; they differ in every important respect, geological structure, geographical characters, and dates of formation. Any theory which assigns the Andes and

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*The term "Rocky mountains" is here apparently used for the Sierra Nevada and Coast Range series of British Columbia. The true Rocky mountains are at a great distance (ranging up to 1000 miles) from the Pacific coast, the trend of which they do not determine.

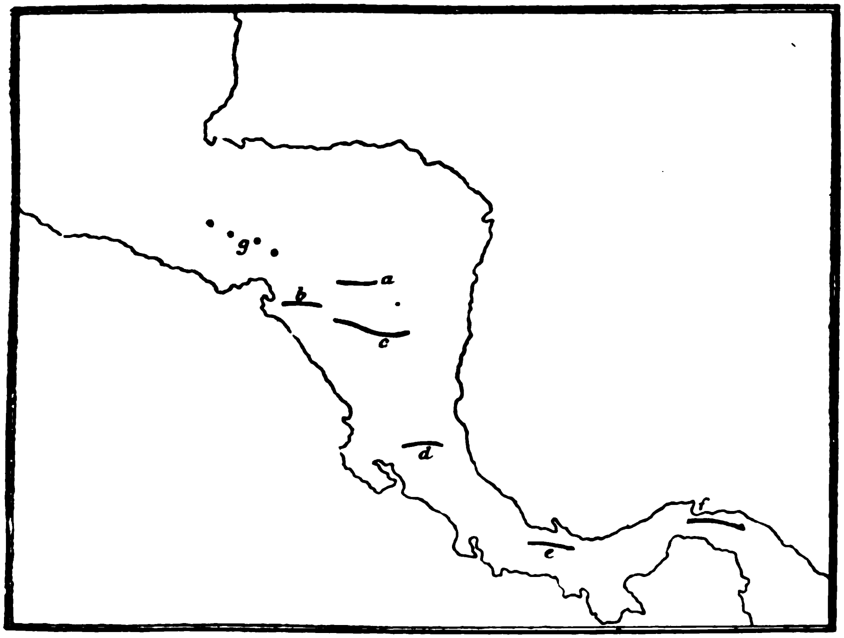

FIG. 3.—THE MOUNTAIN SYSTEM OF CENTRAL AMERICA. *a*, VOLCANIC CHAIN OF HEREDIA; *b*, SIERRA CANDELLA; *c*, CORDILLERA DE DOTA; *d*, SIERRA CHIRIQUI; *e*, SIERRA VERAGUA; *f*, CORDILLERA DE SAN BLAS; *g*, VOLCANIC CHAIN OF ALAJUELA.

***E.g.* the Sierra Candela, Cordillera de Dota, Sierra Chiriqui, Sierra Veragua, Cordillera de San Blas, etc.

the great mountain series on the western coast of North America to a common origin is thereby prejudiced, instead of being supported.

These three theories assign the earth-plan to a venerable antiquity; but there is a fourth theory, which carries it back to an antiquity even more venerable. Lord Kelvin attributes the oceanic and continental areas to a chemical segregation in the gaseous nebula which was the parent of the earth. According to this theory, "Europe, Asia, Africa, America, Australia, Greenland and the antarctic continent, and the Pacific, Atlantic, Indian and Arctic ocean depths, as we know them at present," were all marked out in the primæval gaseous nebula. These gaseous continents condensed to liquid continents marked off from the sub-oceanic areas by chemical differences; and these liquid continents were fixed as the solid continents, hightened by shoaling as the molten globe and its last lava ocean solidified.

That theory appears probable with one verbal amendment —the substitution of the term "archean-blocks" for continents. That these archean blocks—the earth's great corner stones—were embryonically outlined by chemical segregations in the molten or gaseous stages of the earth seems probable. But these archean corner stones, though the foundations of the continents, are not the continents. Lord Kelvin's theory suggests no explanation why chemical segregations should have assumed the shapes of the continents, so that his explanation rests on an unexplained cause; and even if his theory be amended by application to the archean blocks instead of to the continents, the theory is geographically insufficient, as it does not show the relation between the archean blocks and the existing continents.

THE PERMANENCE OF CONTINENTS.

That Lord Kelvin's nebulous segregations, Prof. Darwin's primitive wrinkling, Sir John Lubbock and Prof. Lapworth's double folds are all true causes seems probable. What is doubtful is whether any extensive trace of their influence can be discerned in the present distribution of land and water. A map of the world in early Cambrian times might show the influence of these pre-geological incidents; but their geographical effects seem to have been obliterated by the changes of geological times.

References to such changes reminds us that we cannot assume their occurrence without considering the unending controversy as to the supposed permanence of oceans and continents.

There are, it must be conceded, many weighty arguments in favor of the permanence hypothesis. Many of the last great mountain foldings follow the lines of much older movements; and if the mountain axes, the "backbones of the continents," have occupied the same positions, why not also the continents moulded upon them? Again, some of the great mountain chains, such as the Andes, run parallel to the nearest shore-line, as if the movements that formed them had been deflected by the ocean basin.

The character of the ocean floors, moreover, suggests that they have never been continental, as they are at present covered by deposits not known in the interior of the continents; and as they are supported by material much heavier than that which forms the foundations of the continents.

These arguments, however, are not conclusive. Great earth movements of one date often cut obliquely and transversely across those of earlier periods. Thus the old north-westerly and south-easterly movements of France and Spain have been cut across by the east and western movements of the Pyrenean-Alpine system. Mountain axes have not always been deflected by or limited by existing ocean basins. Thus the north Atlantic basin cuts directly across the old Hercynian mountain chains, which may at one time have extended across the whole Atlantic channel. This is rendered probable by three lines of evidence. Thus in north-western France, and in the south of the British Isles, there is a series of ranges trending north of west, which is cut off abruptly by the Atlantic slope. On the opposite shore of the Atlantic in Newfoundalnd, there is a similar series of truncated ranges formed at the same age as those of western Europe, and having the same trend. Bertrand maintains (1887) that the resemblance between the opposite mountain series is so striking that they should be regarded as parts of one mountain system, of which the central part has been sunk below the Atlantic. The well-known telegraph plateau on which the cables rest may mark the site of this sunken land. Palæontological evidence also supports the formation of the Atlantic by subsidence; for a shallow water, sub-tropical, marine fauna ranged from the Mediterranean to the Caribbean, and can only have crossed along a belt of shallow water in tropical or sub-tropical latitudes. Direct evidence of the existence of shallow water, continental deposits of the age required is given by the Azores, which, although now separated from Europe by a deep depression, contain shallow water deposits with fossils of the Mediterranean fauna.

Thus there is strong evidence to show that the Atlantic, in its present form, is of no great geological antiquity, and Suess' theory of its origin continually gains stronger support. Similar, though less complete, evidence shows that the other ocean basins have been broken up along certain lines, and emphatically denies their entire permanence throughout geological times.

ELIE DE BEAUMONT'S "PENTAGONAL RESEAU."

Hence, if the ocean basins were not formed pre-geologically, but have grown from the changes that have occurred during the long ages of geological time, then we must seek for a cause that has acted continuously, and is acting today. A more permanent cause is supplied by the contraction of the earth's crust, as the globe gradually cools. Since the cold, hard crust is less plastic than the hotter interior, it is necessarily crumpled as it is forced into a smaller space.

This idea is well known, as it has been invoked by geologists to explain the formation of folded mountain chains. That the mountain systems of the world were formed by this agency is improbable; but it is perhaps still too much to say that it is impossible. For Prof. G. H. Darwin has suggested that the contractility of the rocky crust has been exaggerated, and it has been shown that Reade's level of no strain may lie much deeper than was at first thought.

That secular contraction is the direct cause of the great fold-mountain systems is however less widely believed by geologists than it once was; but it may have an important influence in determining their direction. The trend of the great chains of fold-mountains is to us a significant question, because there is much truth in the phrase, proverbial since its use in 1682 by Burnet in his "Theory of the Earth," which describes the mountain chains as the "backbones of the continents." The first geological attempt to explain the plan of the earth was based on this belief. The author of this system was the French geologist Élie de Beaumont, whose theory of geomorphogeny was stated at length in his "Notice sur les systemes de montagnes" (3 vols.: Paris, 1852). This famous theory was based on a correlation of the mountain chains by means of their orientation. Élie de Beaumont accepts the view that the earth consists of a thin rigid crust surrounding a fluid, solidifying interior. The crust being thin, it necessarily collapses as the internal mass contracts. He assumes that these collapses occur at intervals of time, and that at these collapses the crust is broken along lines of weakness, which are crumpled up into mountain chains. He assumes that for practical purposes the earth's crust may be taken as homogeneous; hence that the fractures of the crust would be regularly distributed, and those of successive periods would cross one another along the lines of a regular symmetrical network.

Among the regular simple geometrical forms, that known as the pentagonal dodecahedron, which is enclosed by twelve equal regular pentagons, possesses an exceptionable degree of bilateral symmetry, *i. e.* it can be cut into exactly similar halves in an unusually large number of directions. Sections along any of the edges of any of the pentagons and through the center of the pentagonal dodecahedron divide it into equal and similar halves. So also do sections from the center of the pentagons to any of the angles, and likewise sections across the pentagons from alternate angles. Each face of a pentagonal dodecahedron may therefore be divided by fifteen planes of symmetry.

A sphere may be described upon the pentagonal dodecahedron, so that all the corners (or, to use the correct term, solid angles) occur in the surface of the sphere. By joining the corners by lines, the sphere is marked off into twelve spherical pentagons, which possess the same amount of symmetry as the plane pentagons. The lines where these planes of symmetry cut the surface of the sphere form a network of spherical triangles. Such a network Élie de Beaumont called his pentagonal network, and he used it in the following way. He studied the mountain ranges of the world, and by elaborate calculations showed their relative directions at a few localities which he chose as centres of comparison. He found that many mountain ranges have the same orientation, and that others cross the first set at definite regular angles. The directions of the different sets of mountain ranges coincide with the lines of his pentagonal network. Élie de Beaumont claimed that the mountains whose directions are parallel,* were formed at the same date. Successive mountain-forming movements raised chains parallel to different edges of the network; and thus the intersecting mountain lines of the world, and, consequently, the forms of the continents, were determined.

Élie de Beaumont had no difficulty in pointing out striking coincidences between important geographical lines and his pentagonal network. Thus the Mediterranean volcanic axis, passing through the Grecian archipelago, Etna, and Teneriffe, is parallel to the Alpine chain, and at right angles to the circle through Etna, Vesuvius, Iceland, and the Sandwich Isles. He was able to show a close geometrical relationship between those lines and the line of the Andes, with the pentagon that covers Europe. That the earth is traversed by great intersecting lines is undeniable. *E.g.* Daubrée showed that the valley system of northern France follows a line of rectangular fractures, which he called diaclases. The directions of the Greenland fiords is determined by a similar series of intersecting diaclastic fractures. Bertrand has shown that the movements in the Paris basin, the North sea, and English channel, have followed a double set of orthogonal intersecting lines.

But that the fracture lines or lines of weakness in the earth's crust should intersect more or less rectangularly is natural on any theory of their formation. And such coincidences as those pointed out by Élie de Beaumont in support of his system are inevitable in so crumpled a globe as ours; but they are not sufficiently numerous to be convincing, especially in face of the fundamental differences between the facts of geography and Élie de Beaumont's elaborate artificial system. His theory could

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*For explanation and justification of this use of the word "parallel," see Hopkins, "Presid. Address, Geol. Soc.," *Quart. Jour. Geol. Soc.*, vol. ix. p. xxix.

only be applied to a symmetrical world;* in a dodecahedron the opposite faces are always similar and parallel; in Élie de Beaumont's network the antipodal areas are always similar. But, as we have seen, the fundamental fact in the plan of the world is that opposite areas are dissimilar. In crystallographic language the lithosphere is hemihedral, not holohedral; and no scheme based on a holohedral form will serve. It is the recognition of this principle that led to the next great advance.

THE TETRAHEDRAL THEORY.

Élie de Beaumont's scheme is now mainly of historic interest, though Lefort's recent map of the Nivernais shows that it is still used as a working hypothesis by some French geologists. But Élie de Beaumont's theory marked an epoch in this subject, for it led to the system of Mr. Lowthian Green, which far better meets the requirements of the case.

This system was founded in 1875, by Mr. Lowthian Green, in a work which was neglected or ridiculed at the time of its appearance. Like his predecessor, Green assumes that the earth is a spheroid based on a regular geometrical figure. He adopted as his base the apparently hopelessly unsuitable figure of the tetrahedron, which is contained within four equal similar triangles. This form, with its four faces, six sharp edges and four solid corners, does not conform to the ordinary conception of the figure of the globe. Any comparison between them looks ridiculous. But if we place a three-sided pyramid on each face of the tetrahedron, its proportions are nearer those of a globe; and if these pyramids had elastic sides so that they could be blown out and the faces thus made curved, then the tetrahedron would become spheroidal and even spherical. Conversely, if a hollow sphere be gradually exhausted of air, the external pressure may force in the shell at four mutually equidistant points, and, by the flattening of these four faces, make it tend towards a tetrahedral form. Now the tetrahedral theory does not regard the world as a regular tetrahedron with four plane faces; it considers that the lithosphere has been subjected to a slight tetrahedral deformation, to an extent indeed only faintly (if at all) indicated by geodetic measurements, but yet easily recognizable owing to its influence on the distribution of land and water. As the centres of the flattened faces are nearer the earth's center of mass than the edges, the water will collect upon them. The ratio of the area of land to that of water on the globe is as 2 to 5. If on a model of a tetrahedron we color the five-sevenths of the surface that is nearest the centre, the colored areas would show where the water would collect if the earth were a stationary tetrahedron. On the upper face there is a large central colored area in the position of the Arctic ocean. It is surrounded by a land belt, from which three projections run southward down the three lateral edges. These three land areas taper southward to a point, below which is a complete belt of sea. South of that, again, is our fourth projecting corner, which is above the water-level, and is the Antarctic continent. So that on the model the general plan of the arrangement of land and water is identical with its actual distribution on the globe. For the land occurs as three triangular equidistant continents, united above into a ring and tapering southwards; there is a great excess of water in the southern and of land in the northern hemisphere; and land and water are antipodal, since in a tetrahedron a corner is always opposite a flat face.

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*This objection applies also to various later modifications of Élie de Beaumont's principle, such as those of Owen; or to the more than local acceptance of the diaclases of Daubrée, or orthogonal cross-folds of Bertrand.

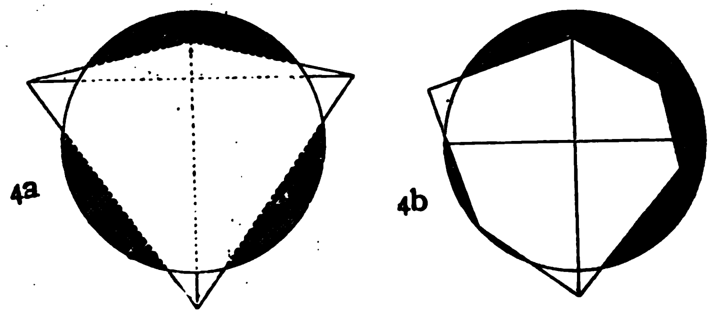

FIG. 4.—RELATIONS OF A TETRAHEDRAL LITHOSPHERE TO ITS HYDROSPHERE. FIG. 4a REPRESENTS THE ARRANGEMENT IN A SIMPLE TETRAHEDRON. FIG. 4b ILLUSTRATES THE CASE OF A MODIFIED TETRAHEDRON (SUCH AS SHOWN FIG. 5b) BY A SECTION PASSING ON THE LEFT THROUGH A TETRAHEDRAL COIGN, AND ON THE RIGHT THROUGH THE OPPOSITE TETRAHEDRAL FACE. THE SHADED AREAS REPRESENT WATER.

But of course in the earth the faces are not flat, but are convex. If the flat faces be replaced by projecting pyramids with curved faces, so that the form is globular, the arrangement of land and water remains the same, but the shore-lines are more complex. Green has shown what the shapes of the land and water areas would be in such a tetrahedron. The resemblance between his diagrammatic continent and Africa and S. America, and between his ocean and either the Pacific, Indian ocean, and S. Atlantic, is very striking.

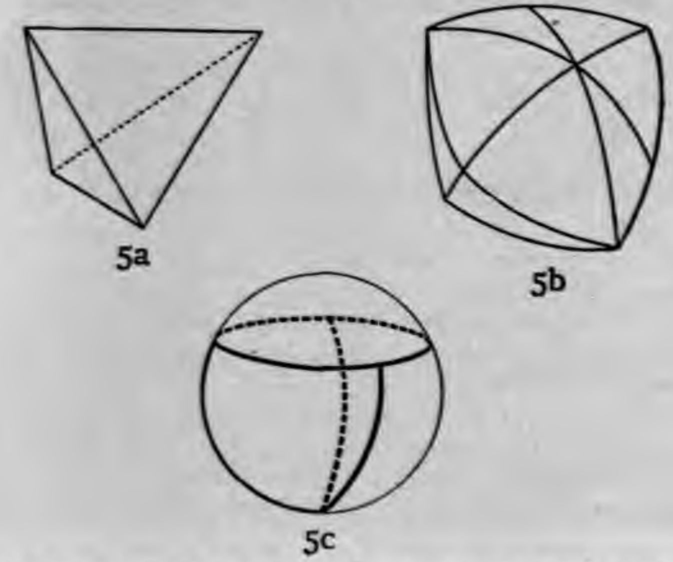

FIG. 5.—5a, DIAGRAM OF A SIMPLE TETRAHEDRON.—5b, DIAGRAM OF A TETRAHEDRON WITH A SIX-FACED PYRAMID WITH CONVEX FACES ON EACH OF THE FOUR FACES.— 5c, THE TRACE OF THE TETRAHEDRAL EDGES ON A SPHERE; THE THICK LINES SHOW THE POSITION OF THE TETRAHEDRAL EDGES.

THE TETRAHEDRAL COURSE OF GEOGRAPHICAL LINES.

The agreement between the facts of geography and the tetrahedral theory goes further. The four faces of a tetrahedron meet along six edges, which should be lines of elevation on a globe. The trace of the edges of a tetrahedron on a surrounding sphere forms a circle in the northern hemisphere, and three vertical or meridional edges meeting at the south pole.

In the earth the major watersheds have exactly this arrangement. The great watershed of Eurasia dividing the northern and southern drainages, runs, not along the main mountain axis, but far to the north of it, between the parallels of 50° and 60°. The northern and southern slopes of North America are separated by a divide along the same latitude. The southern watersheds, instead of following the lines of highest mountains, or the middle line of the continents, run close to the coast-lines; the three watersheds mark the three vertical tetrahedral edges, and they occur at almost the theoretical distances, 120° apart.

Similarly with the mountain chains. As Sir John Lubbock has pointed out, "in the northern hemisphere we have chains of mountains running east and west, the Pyrenees, Alps, Carpathians, Himalayas, etc.—while in the southern hemisphere the great chains run north and south—the Andes, the African ridge, and the grand boss which forms Australia and Tasmania." That is to say, the northen mountains are parallel to the upper edges, and the southern mountains are parallel to the meridional edges of the tetrahedron.

THE CAUSE OF THE TETRAHEDRAL PLAN.

The statement that the elevations of the lithosphere are tetrahedral in arrangement is not a hypothesis, but a simple statement of geographical fact. Is the fact a mere coincidence? On the contrary, there are good reasons why the earth should acquire such a tetrahedroid symmetry. When the earth solidified, it would (neglecting the influence of rotation) have contracted into a spherical shape. It would have tended to acquire this form because the sphere is the body which encloses the greatest volume for a given surface. But as the earth contracts it tends to acquire a shape in which there is a greater surface in proportion to its bulk. Now, among the regular geometrical figures with approximately equal axes, the tetrahedron is that which contains the smallest volume for a given surface. Hence every hard-shelled body which is diminishing in size, owing to internal contraction, is constantly tending to become tetrahedral in form. Fairburn's experiments (quoted by Green) illustrate this tetrahedral collapse for short tubes; and that it is considered probable by some geodists is shown by the following quotation from E. D. Preston: "Nothing is more in accordance with the action of physical laws than that the earth is contracting in approximately a tetrahedral form. Given a collapsing homogeneous spherical envelope, it will assume that regular shape which most readily disposes of the excess of its surface dimensions; or, in other words, the shape that most easily relieves the tangential strains; for, while the sphere is of all geometrical bodies the one with a minimum surface for a given capacity, the tetrahedron gives a maximum surface for the same condition. Experiments on iron tubes, on gas-bubbles rising in water, and on rubber balloons, all tend to bear out the assumption that a homogeneous sphere tends to contract into a tetrahedron."

(To be continued.)

REVIEW OF RECENT GEOLOGICAL LITERATURE.

Jovellania triangularis im Mitteldevon der Eifel, von E. KAYSER (Centralblatt für Mineralogie etc., 1900, p. 117.)

The occurrence of this well known Devonian species of Archaic in loose fragments along with a characteristic middle Devonian fauna at Lissengen in the Eifel is described. G. F. M.

A brief review of the titaniferous magnetites. By J. F. KEMP. (*School of Mines Quarterly, 20.* 323-356; *21,* 56-65.)

The known deposits of magnetic iron ore may be conveniently classified into two groups on the basis of chemical composition; the titaniferous and the non-titniferous. This grouping not only corresponds to the chemical composition, but also to the geological relations and to the present utilization and non-utilization.

Among the magnetic ores the non-titaniferous are today the only ones mined and smelted and even their productiveness has decreased notably in recent years, because of the great influx of cheap and easily reduced hematites from lake Superior. The Cornwall banks in Pennsylvania are almost the only large American magnetite mines now in active operation. The geological relations of the non-titaniferous ores are variable, and, in one place and another, they have resulted from very different originals and by strongly contrasted processes, but if titaniferous iron sands are omitted, the massive titaniferous ore-bodies may be said to be closely allied in character and origin wherever they have been studied. With one or two exceptions the titaniferous magnetites are associated, so far as known, with rocks of the gabbro family and furnish a distinct type of ore body, that is singularly uniform the world over. They constitute, in most cases, large irregular masses in the midst of intrusions of igneous rock and seem to have been produced by the segregation of fairly pure titaniferous iron oxide, either before or during the process of cooling and consolidation. In less common instances the entire mass of the dike or stock is so enriched with the iron-bearing mineral as practically to be considered an ore. Although the ores are not at present the objects of active mining, yet the quantity is so large and the iron afforded has such peculiar advantages of its own, doubtless owing to certain chemical elements generally present in the ore, that it seems improbable that they will long go without utilization. The wall-rocks, referred to as belonging to the gabbro family, form an extended series including anorthosyte, true gabbro, noryte, diabase and peridotyte. To them must be added the Brazilian nepheline-plagioclase rock and the nepheline-syenyte at Alno, Sweden. In their mineralogical composition the ores involve both ilmenite and titaniferous magnetite. The latter may be strongly magneitc while high in TiO. The strong magnetism of some titaniferous magnetite shows the improbability of removing the titanium by magnetic concentration. In most cases, while the iron is increased in the concentrates by the elimination of the ferro-magnesian silicates, the titnium is also increased. In their chemical composition the ores are characteristic and marked. As a rule, but not invariably, phosphorus and sulphur are notably low or entirely absent. Vanadium, chromium, nickel and cobalt are almost always present, and they may together amount to several per cent. Magnesia and alumina are often far in excess of what would be required for silicates and then they are doubtless combined with more or less iron in spinels. Lime is of course involved in the presence of the pyroxenes and related minerals and manganese is often, but not invariably, at hand. This paper consists after the brief introduction, of summary descriptions, in geographic sequence, of the chief deposits of titniferous magnetite now known. The descriptions are accompanied by analyses to the number of more than one hundred seventy which illustrate for each region the range in composition. This work is thus a complete resumé; and the citations place the reader in command of the literature. W. O. C.

The Origin of Kaolin. By HEINRICH RIES. (*Trans. Am. Ceramic Soc.,* 2, Feb. 1900.)

Defines kaolin as any residual clay sufficiently free from iron to burn to a white or nearly white color, and derives kaolin from feldspathic minerals, in part through the agency of carbon dioxide and the ordinary weathering processes (shallow deposits) and in part, as suggested by Von Buch and Daubrée, through the agency of ascending acid vapors, including chiefly hydrofluoric acid (deep deposits). Collin's experiment and analyses are cited in support of the latter explanation; but all the economic deposits of the United States are referred to the former. Kaolins containing undecomposed mica can not be referred to the fluoric type. The practicability of correlating rational analyses of kaolin with the original minerals and the method of deriviation is also considered. W. O. C.

Igneous Complex of Magnet Cove, Arkansas. By HENRY S. WASHINGTON. (*Bull. Geol. Soc. Am., 11,* 389-416.)

This paper is an able and timely review, in the light of the modern ideas of magmatic differentiation, of the limited and isolated area of plutonic rocks so carefully mapped and described to J. F. Williams ten years ago. The scope of the paper is clearly and tersely indicated in the author's summary, from which the reviewer quotes. The structure of the complex is briefly described, and from the evidence of its broadly elliptical outline, relations to surrounding shales, the presence of an overlying zone of metamorphosed rocks, the arrangement and serial petrographical and chemical characters of the main types, together with other minor points, it is shown that the igneous complex is probably a laccolith, and certainly a unit or integral mass of intruded magma. The component abyssal types are not due to successive injections as was suggested by Williams, but are the products of a differentation in situ of the originally homogeneous mass of intruded magma ("laccolithic differentation" of Brögger). The main rock types are briefly described, some new analyses being given; and they are shown to form a regularly graded series, ranging from foyayte, through leucite-porphry, shonkinitic syenyte, normal ijolyte and biotite ijolyte to jacupirangyte. This serial and common genetic character is shown both mineralogically and chemically. It is probable that the dikes of tinguayte and nepheline porphyry are aschistic (undifferentiated injections of the still fluid differential zones into the surrounding rocks), while those of the monchiquitic rocks are diaschistic (products of a still farther differentiation of these zones). The arrangement of the abyssal rocks is abnormal and differs radically from most other cases of differentiated masses, in that there is progressive increase in acidity toward the periphery, the analagous case at Umptek in Kola being especially mentioned. An explanation of this is based on a process of fractional crystallization or freezing of the magma, which is regarded as a solution, the solvent crystallizing first, is given; and the hypothesis is applied to other cases. It is suggested that all laccoliths and similar masses of magma may be referred to at least four different types, dependent on the chemical composition of the magma as a whole, the differences between which would be satisfactorily accounted for by the hypothesis. In the opinion of the reviewer, the explanation of this contrast between the normal centripetal acidity and the abnormal centrifugal acidity of plutonic masses might be strengthened and simplified by recognition of the important role as a solvent of water, which, so far as known, is universally present in magmas, and is the one important constituent which never freezes. W. O. C.

A Granite-Gneiss Area in Central Connecticut. By LEWIS G. WESTGATE. (*Jour. Geol., 7,* 638-654.)

This is purely a petrographic paper, describing an elliptical area

of gneissoid granite on the Connecticut river east of Middletown. The phenomena and inclusions of the inclosing schists prove the granite to be intrusive, in spite of the marked and persistent foliation. It assumes frequently the character of an "augen"-gneiss. Basic segregations or schlieren of dark color and fine grain are a common feature, strengthening the proof of an igneous origin, as do the asociated dikes of pegmatyte and the contact zone of granulyte. The component minerals, from which the chemical composition may be approximately deduced, are chiefly quartz, various feldspars and biotite, the feldspars including most abundantly orthoclase, with an acid plagioclase and subordinate microcline. The accessories include titanite and a very little apatite and magnetite. In the granulyte garnet is the chief or only accessory. W. O. C.

The Origin of Nitrates in Cavern Earths. By WILLIAM H. HESS. *(Jour. Geol., 8,* 129-134.)

The nitrates are not derived from the excrement of bats, as popularly supposed, but have their origin in the oxidation or nitrification of organic matter in the surface soil through the agency of bacteria, and the subsequent leaching of the nitrates so formed downward into caverns, where they slowly accumulate with other salts as the water escapes by evaporation. This explanation is in harmony with the fact that bats penetrate but short distances from the entrance to a cavern, while the distribution of the nitrates is entirely without reference to the entrance, the cavern earh of the Mammoth cave having been worked for nitrates for a distance of over five miles from the only opening to the surface. Three analyses show that nitrates form but a small part of the soluble salts of the cavern earth, which include also sulphates and chlorides, and may aggregate as much as 13 per cent. The general conclusion as to the origin and source of the nitrates is sustained by a comparison of analyses of the soluble portions of (1) subsoil from the surface above the Mammoth cave, (2) cavern earth from the subjacent part of the cave, (3) bat guano, and (4) cavern earth immediately below the bat guano. A comparison of bulk analyses of bat guano and cavern earth follows; and it is suggested that the calcium phosphate of the latter cannot be referred to the former, since the insolubility of this salt makes it a necessary residuary product of the solution of limestone. Analyses show that the water dripping from the roofs of caves is not markedly different from ordinary sub-drainage waters. The nitrates and other soluble salts accumulate only in the earths of relatively dry caverns, or where the inflow of water does not exceed in amount the water removed by evaporation; and numerous analyses show that all dry caves contain nitrous earths. Nitrates found under overhanging cliffs are of a similar origin—evaporation of water which has percolated through the soil; and essentially the same explanation will fit the case where nitrates accumulate on the surface of a manure heap, through the joint action of capillary attraction and evaporation. W. O. C.

Igneous Rock-Series and Mixed Rocks. By ALFRED HARKER. (*Jour. Geol., 8,* 389-399.)

A rock-series is defined as an assemblage of rock-types, with a certain community of characters, associated in the same district, belonging to the same suite of eruptions and holding a similar position in the scheme of igneous rocks belonging to that suite. According to the differentiation hypothesis, they are derivatives of the same order from one common source, resulting from differentiation along similar lines and to the same degree. The fundamental characteristics of such a series, having regard to chemical composition, are of two kinds: (1) those belonging to the individual rock-types and shared by all the types included in the series; and (2) those belonging to the assemblage of types as a whole, depending upon variations in the composition of the members as compared with one another. These characteristics admit of very clear graphic presentation. For this purpose the method of two equal rectangular co-ordinates first used by Iddings is recommended, silica being referred to one axis and bases to the other; and the resulting curves are briefly discussed. The origin of ingeous rocks by admixture rather than by differentiation is next considered, and three principal cases are distinguished: (1) mixture of two fluid magmas; (2) permeation of a solid rock by a fluid magma; and (3) inclusion of rock fragments in a fluid magma. The second and third cases are practically limited to igneous rocks of cognate origin; and the distinction of. the included and permeated rocks or xenoliths as accidental and cognate is regarded as important; the latter only yielding by their absorption new rocks of any considerable extent or importance. Several cases are considered, including the admixture of two rocks of the same rock-series, and the solution by a magma of extraneous quartz, and of limestone. The admixture of the extreme types of a series will not, in general, give exactly any of the intermediate types. The rock-analyses of Clarke and Hillebrand are cited in illustration of this principle; and it is pointed out that mixtures, even of two normal igneous rocks and still more of an igneous and a sedimentary rock, must often be abnormal in chemical composition. The relations of the chemical composition of the magma and of foreign admixtures to the mineralogical compostion are also considered.

The Sundal Drainage System in Central Norway. By R. L. BARRETT. (Bulletin American Geographical Society, No. 3, 1900.)

The young Sundal drainage system, on the northern coast of central Norway, possesses deep gorges and canyons which drain northwest into the Atlantic. It is closely related to, but divided from, the comparatively shallower and more or less disconnected valley system of the Opdal, which drains northeast but also reaches the Atlantic.

The divide between these two systems has been shifted from east to west, as has been the case in a less degree in the two drainage systems just south of the Sundal, the Eikedal and the Ronesdal.

The paper presents facts to prove that the divide in question once stood near the head of the Sundal fjord, more than sixty-five kilometers west of its present position, and also shows that the processes which shifted the divide and reversed the drainage are largely responsible for the peculiar features of the Sundal system, namely, its deep canyons and high shallow tributary valleys.

The author reconstructs the mature valley system (Opdal), describes the young canyon system, shows the relation existing between the two and offers explanations for these relations. He discusses as factors in the reversal of drainage: guided headward erosion by the Sundal system and capturing of the Opdal branches, unguided headward erosion and capturing, erosion by the outlets of ice-dammed lakes which overflowed from the Opdal to the early Sundal system and glacial erosion.

The text is accompanied and elucidated by five diagrams which put the whole story in clear and concise form. The paper is an admirable result of thorough investigation in the field and laboratory.

F. B.

Bulletin No. 4, of the South Dakota School of Mines, Department of Geology. PROF. C. C. O'HARRA. April, 1900. Rapid City, S. Dak.

This pamphlet, containing 88 octavo pages, with several plates reproducing old maps, furnishes an exact and very useful epitome of the literature of the geology of the Black Hills. Many of the old papers, now very rare, beginning with those of Dr. Prout in 1846, are annotated. The first portion of the bulletin sketches rapidly the progress of geological investigation in the Black Hills region, giving some account of the parties and the routes they followed. The earliest mention of the hills is in Lewis and Clarke's report of their expedition in 1804-05-06, where they are credited with glaciers, although this must have been incorrect—or at least it cannot now be affirmed of the region known as the Black Hills. The author mentions fully the work of Dr. Evans in the "bad lands," reported by Dr. Owen in his report on Iowa, Wisconsin and Minnesota, of Dr. F. V. Hayden and Mr. F. B. Meek, Dr. Leidy, Lieut. G. K. Warren and others to 1900.

N. H. W.

MONTHLY AUTHOR'S CATALOGUE

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PERSONAL AND SCIENTIFIC NEWS.

Dr. Otto Nordenskjold, of Upsala, is preparing a south polar Swedish expedition which will be ready to start probably, in the fall of 1901.

Dr. R. A. Daly of Harvard University is planning the organization of a summer excursion to Iceland, western Greenland and Labrador, conditioned on the formation of a sufficiently large party leaving Boston on or about June 26, returning about September 20.

Professor E. H. Williams, Jr., of the department of mining and geology, has equipped a geological laboratory for the microscopic study of rocks at Lehigh University.

Profs. A. J. Moses and L. M. Luquer contribute to the *Journal of Applied Microscopy* abstracts of mineralogical literature, American and foreign.. These are particularly valuable in the mathematical and physical, especially the optical, characters.

Prof. H. B. Patton, of the Colorado School of Mines, Golden, Colo., offers a list of rare Colorado minerals and of rocks, for exchange with institutions which may have others for such disposition.

Geological Society of Washington. At the meeting of January 23rd the following was the program: "The geologic age of Shell bluff, Ga., one of Lyell's original localities," T. Wayland Vaughan; "Trias in northeastern Oregon," Waldemar Lindgren; "Comparison of the Ouachita and Arbuckle mountain sections, Indian Territory," J. A. Taff; "Age of the coals at Tipton, Blair county, Pa.," David White.

The Lake Superior Mining Institute will hold its seventh meeting in the copper district of Michigan on March 5 to 8. The headquarters will be at Houghton.

Geological Society of America.—The regular winter meeting was held at Albany, N. Y., presided over by Dr. G. M. Dawson, who gave an ex-augural address on "The Geological record of the Rocky Mountain region." The session continued through Dec. 27, 28 and 29, and was attended by about thirty geologists. A large number of papers were read. A reception was given the Society by the state geologist, Dr. F. J. H. Morrill, at his residence, evening of Dec. 28, and the usual subscription dinner occurred Dec. 27. The Society assembled, and held its meetings, in the Albany Boys' Academy, in the room in which Henry demonstrated publicly the possibility of the electric telegraph. The president-elect is

C. D. Walcott. The next winter meeting is planned to occur in Chicago.

GEOLOGICAL SOCIETY OF AMERICA, CORDILLERAN SECTION—The western, or as it is called the Cordilleran section of the Geological Society of America, was established by a few of the geologists of the western coast whose distance precludes them from joining their fellow members of the eastern part of the continent, save on rare occasions. The second annual meeting of this section was held on Friday and Saturday, the 28th and 29th of December, at the State University of California, at Berkeley. Prof. W. P. Blake, of the University of Arizona, presided on the former day and Prof. W. C. Knight, of Laramie, Wyoming, on the latter.

The first meeting was held in the council room of the California Academy of Science at San Francisco, and the other at the state university, Berkeley, where all arrangements for the convenience of visitors had been made by the secretary and other resident members. Prof. Andrew Lawson, of Berkeley, secretary of the section, was also the secretary of the meeting.

The following summary will show the course and scope of the proceedings:

Prof. Blake read the first paper, and in it he gave the evidence for the existence of any ancient, probably Cambrian, sandstones and quartzytes, on the granite of Arizona. He also mentioned the existence of limestone with *Atrypa reticularis* and of quartzytes with Devonian fossils. In the Santa Catarina mountains are uncrumpled strata, probably the equivalents of the Huronian and Laurentian of Canada, and also much crumpled beds of mica-slate standing nearly vertical.

Reference was also made to beds of pegmatyte and in the discussion that followed to very thick strata of Cambrian dolomytes with strata of quartzytes penetrated by intrusive granites of Cambrian date. The paper was followed by considerable discussion, in which most of those present took part.

Prof. E. W. Claypole, of Pasadena, next spoke of the structure of the Sierra Madre and the valley of Pasadena. This range is apparently a continuation of the ranges of the Santa Lucia and the San Rafael mountains, and consists of two materials. The front or southern face is composed of a very highly hornblendic granite which by the oxidation of iron is subject to rather rapid and deep weathering. Erosion is consequently severe and the existence of crags and cliffs is rendered difficult. Behind this and forming the higher portion is a white feldspathic gneiss containing very little hornblende and weathering less rapidly. Of this consist the crags and scarps so conspicuous from the valley. The valley is almost entirely made up of detrital material derived from the destruction of the Sierra—often many hundreds of feet deep and consisting of strata of gravel and sand. These form the great water-storage of the region and during the past dry season they have been exploited in the search for water and have proved vastly more productive than had been previously believed. The possibility of largely increasing the productiveness of the valley of Pasadena and the plain of Los Angeles has consequently been rendered almost a certainty. The paper concluded with a few notes on the method now in course of adoption for further increasing and storing the rainfall.

On Friday afternoon Prof. E. W. Hilgard, of the agricultural department of the University of California, spoke on the soils of the state and the mode of their formation, the power of kaolinization, the effect of wind and the origin of adobe. He pointed out the difference between the soils of the dry and the humid regions, maintained that few of them needed "liming" or, as it is called, "marling," as there is usually present from 1 to 2 per cent of lime in some form or other, a large part of which is the carbonate. He showed that most of these aluminous soils retain the potash resulting from the decomposition of the orthoclase and that in many cases this, in the soil of the surface alone, amounts to 1200 to 1800 pounds per acre.

Much of the sandy soil of the state needs only water to become abundantly fertile, if tolerably free from alkali (chiefly carbonate of soda) and the dryness of the superficial soil forces the roots to penetrate it to a much greater depth than roots do in moister regions. In consequence of this fact crops which there would be killed by a long drought are here able to survive and even flourish for months without any rain.

F. M. Anderson, of Berkeley, described the river system of northern California and the Klamath mountains. The latter, he said, contain two sets of flexures at nearly right angles to each other but not coeval. The streams have the level intermontane areas, in many cases, by narrow canyons, indicating an immature topography. Deposits of Chico, or Upper Cretaceous, age occur on the north and south sides of the Siskiyou river, shaly below and conglomeratic above.

The lavas of the Cascade mountains are of different ages; the oldest eruptive are certainly of a date before the deposition of the Chico, or Upper Cretaceous, beds and between them and the later beds lie the Ione deposits. Near the head of the Siskiyou river there are indications of four distinct periods of volcanic activity. In some of the tuffs are petrified fragments of wood and under some of the andesitic beds are specimens of unmineralized wood, black and scorched. This and the drainage of the region which is antecedent indicate the very recent date of the eruption.

H. W. Fairbanks, of Berkeley, spoke on a group of volcanic peaks called "The Three Sisters" in central Oregon. They rise to a hight of 10,000 feet, and among them lies a glacier nearly three miles long and half a mile wide., The paper was illustrated by a number of slides, showing the mountain and the topography of the region. The recency of volcanic activity is proved by the superposition of the lava on glaciated surfaces of the rock and by the presence of a small volcanic cone in the path of the glacier which has not been able to destroy or seriously erode it.

Prof. A. C. Lawson presented a series of arguments drawn from the superficial structure of the region tending to show that the elevation of the Sierra Nevada was in date later than that of the Coast ranges. He argued that the river-valleys of the two regions presented marked differences—that the drainage in the Sierra Nevada is consequent and the system therefore immature, while in the Coast range the drainage is subsequent and the geomorphy mature. Illustrations were drawn from the branches of the Klamath, Eel and Sacramento rivers in support of the views advocated in the paper.

Prof. Lawson also spoke briefly on a specimen of feldspar-bearing corundum, from Plumas county, California, which occurs as a dyke cutting serpentine on the eastern flank of Spanish peak. He spoke of the rocks as supersaturated with alumina, and said, the feldspar was an oligoclase containing by an analysis 16 per cent of corundum.

Prof. J. C. Merriam, of Berkeley, spoke of the John Day beds exposed on the river of the same name. The canyon is cut through an immense series of strata about 10,000 feet in thickness and ranging from the Jurassic to the Quaternary and composed of nine or ten distinct beds. These include large quantities of volcanic tuffs and ashes, with andesitic and rhyolitic lavas lying on the John Day beds and tilted with them to an angle of 30° over which are seen 1,500 feet of Columbian lavas. The abundance of land shells of such genera as *Helix*, the scattering of the bones of the skeletons and the absence of fish remains were mentioned as tending to cast some doubt on the lacustrine nature of the deposit. Ten skeletons have been found whole and very few plant remains occur. The Cretaceous beds are of the age of the lower Chico.

Mr. H. M. Turner, of Washington, D. C., spoke on the Geology of the Great Basin in California and Nevada. The address was illustrated with lantern slides. The ridges of the western edge of the Great Basin in Nevada and eastern California, are usually very complex in structure and composition. They comprise sediments of Paleozoic and Juratrias age much disturbed at some points by intrusions of granolytes. In Tertiary time there were extensive lakes, and contemporaneous with these lakes, and also later, lavas and tuffs in large amount, chiefly rhyolytes, andesytes and basalts. The formation of the ranges or at least their latest uplifts date from the Tertiary or post-Tertiary. They were elevated along normal faults, the valleys being subsided areas, often of the nature of rock basins, whose rims are made up of rocks older than the desert detritus.

There are some gneisses pretty certainly of pre-Cambrian age. These gneisses underlie lower Cambrian slates and limestone There is an extensive chert series rich in graptolites supposed to be of lower Silurian age. There are also lower Trias beds in the Inyo range and in the Pilot mountains Jurassic limestone and slate. The Tertiary lava beds contain abundant plant, molluscan and fish remains.

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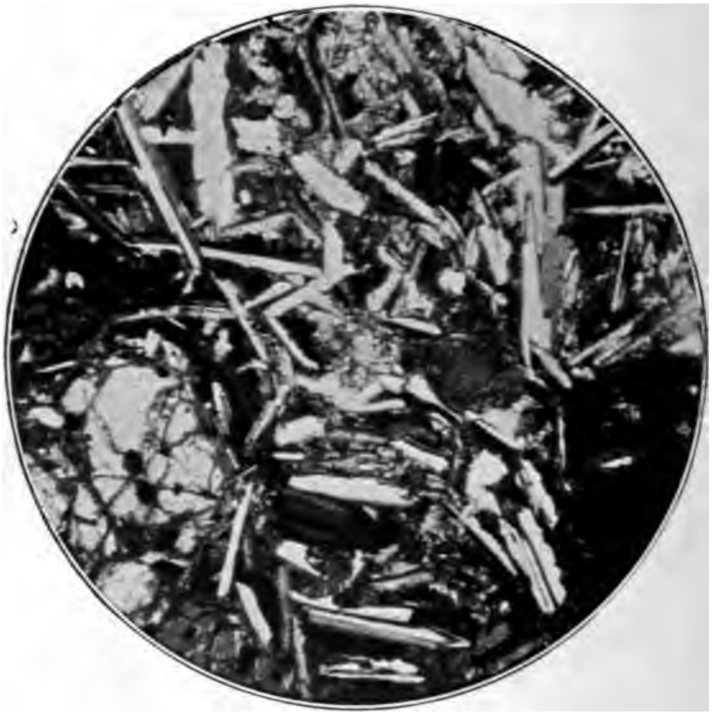

THIN SECTION OF OLIVINE DIABASE, FIVE MILES NORTH OF MACON, GA., AS IT APPEARS UNDER CROSSED NICOLS X 75.

THE

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SOME NOTES ON THE TRAP DIKES OF GEORGIA.

By S. W. McCALLIE, Atlanta, Ga.

Plates XII–XIV.

The trap dikes of Georgia are confined to what is known as the Crystalline area, an old land surface, occupying the central and northern part of the state. This area is made up largely of schists and gneisses with numerous intrusive bosses of granite. The schists and gneisses occur chiefly in alternate bands or zones having a northeast-southwest trend. The dikes are pretty evenly distributed throughout the area and are found mostly in groups which consist of one large, or mother dike, paralleled on one or both sides by smaller dikes.

The larger dikes often attain a maximum width of 200 feet and sometimes extend for many miles with but few interruptions. A good example of one of the larger dikes is to be seen in a cut on the Central railroad, a few miles east of Newnan in Coweta county. This dike continues for about sixty-five miles in a southern direction through Coweta, Meriwether and Talbot counties, finally disappearing beneath the Columbia sands some four miles south of Talbotton. Within this distance there occur a few breaks or interruptions a mile or more in length due either to an actual discontinuity of the dike or its burial beneath the residual products derived from the enclosing schists.

The smaller dikes vary from an inch to a yard or more in width and never continue for more than a few hundred rods. In some localities these smaller dikes are quite numerous. On the Georgia railroad near Covington as many as seven of these dikes are to be seen within a short distance of each other. The dikes as a general rule all have a vertical dip, and a northwest-southeast trend, thereby invariably cutting the gneisses and schists at a considerable angle. In some instances the large dikes, owing to their slow weathering, have given rise to low, flat ridges whose sides are usually strewn with innumerable rounded bowlders, locally called "nigger-heads."

All of the trap dikes throughout the Crystalline area appear to be of the same age and are formed of similar rock material. They are evidently of a comparatively recent geological age as is shown by their undisturbed condition. They rarely ever reveal any evidence of shearing or any other indication of a general earth movement. Along the southern margin of the Crystalline area between Macon and Milledgeville at a point on the Georgia railroad, near James' Station, a dike comes in contact with clay beds which have been classed by Dr. Geo. E. Ladd as Tertiary beds.* The exposure here, however, is limited and gives no satisfactory evidence as to the relation of the dike to the Tertiary clays. A further study of the dikes along the above contact will probably demonstrate that they are of Jura-Trias age, and belong to the same system as the trap dikes of the Carolinas and Virginia.

The rocks of the dikes are quite compact, fine-grained and of a dark-gray, or almost black color. They are typical diabases made up of plagioclase and augite with olivine and magnetite as the chief accessory minerals. The plagioclase occurs in the form of long, slender, lath-shaped crystals, which are frequently enveloped in large irregular plates of augite, thus exhibiting a beautiful ophitic structure.

THE PLAN OF THE EARTH AND ITS CAUSES

By J. W. Gregory, D.Sc., Melbourne, Aus.

(*Continued from p. 119.*)

THE EARTH A GEOID.

But it may be said this tetrahedral theory is impossible, because we know from our elementary text-books that the earth is not terahedral, but is an oblate-spheroid—that is to say, a sphere slightly flattened at the poles.

The oblate spheroid is no doubt the form that rotation would have caused the earth to assume as it solidified, if the earth were quite homogeneous. But the earth is not homogenous; it varies in strength and density, and an unequal load on the earth in any area leads to a divergence there from the circular shape. It is, I believe, now universally admitted that the earth is flattened laterally at the equator as well as at the poles. The question was long disputed between the astronomers, who, from theoretical considerations, declared what the shape of the world ought to be, and the geographers, whose measurements showed what the shape actually was. There is now a general agreement that the geographers were right; that the equatorial section of the earth is elliptical, similar to a section through the earth passing across the poles. The earth is therefore not a true spheroid, and it was accordingly regarded as an ellipsoid with three unequal axes. But there is good reason to believe that the earth is not even an ellipsoid; for the northern and southern hemispheres are unlike, and the earth is therefore shaped like a peg-top. This is shown in two ways. It is a well known property of the ellipse that degrees measured along the flatter side are longer than degrees measured near the sharper end. It was by proving that a degree of latitude in Lapland is longer than a degree of latitude in Ecuador that the French astronomers in the seventeenth century definitely proved the earth's flattening at the poles. In continuation of these observations, La Caille, in 1751, measured the length of a degree at the Cape of Good Hope. His measurements showed that the southern hemisphere was also flattened, but to a different extent than the northern hemisphere. This anomalous result of La Caille's was confirmed and extended by Maclear.

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* *The American Geologist*, vol. xxxiii, pp. 248.

The inequality of the two hemispheres has also been shown by the variations of gravity in the two hemispheres, which, as it is more easily tested, has been more widely applied. The principle is simple. A pendulum swings more rapidly the nearer it is brought to the centre of the earth. A pendulum swings more slowly on a mountain-top than at sea-level. It was because Richer, in 1672, found that a clock which kept correct time at Paris lost two minutes a day in French Guiana that the polar flattening was first suspected. So many observations have been made that maps have been compiled showing the variation of the force of gravity throughout the globe. Fig. 6 is a

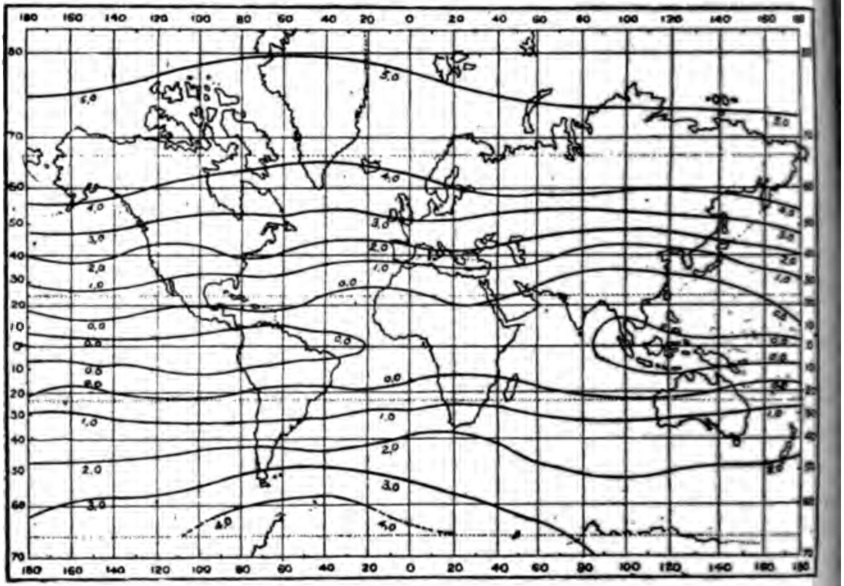

FIG. 6.—STEINHAUSER'S MAP, SHOWING VARIATION IN ATTRACTION OF GRAVITY, AS INDICATED BY LENGTH OF THE SECOND-BEATING PENDULUM. 0 = LENGTH IN EQUATORIAL BELT; 1-5 = NOS. OF MILLIMETRES BY WHICH A PENDULUM HAS TO BE LENGTHENED IN ORDER TO BEAT SECONDS AT DIFFERENT LATITUDES.

copy of Steinhauser's map, in which the variation of gravity is illustrated by showing how many millimetres have to be added to the length of the pendulum which beats seconds at the equator, to make it vibrate at the same rate elsewhere. In both northern and southern hemispheres the second-beating pendulum has to be steadily lengthened as we approach the poles, but the deviation is at a different rate for the two hemispheres. The surface of the southern hemisphere does not approach the earth's centre of mass at the same rate as the northern hemisphere. If the earth's centre of mass is at its geometrical centre, then the earth's form is elongated southward like a peg-top. It is often held that the earth's centre of mass is to the south of its center of form, because of the accumulation of water in the southern hemisphere. It is held that the water is piled up there, owing to the greater density of the southern hemisphere. If that be the case, then the peg-top elongation is all the greater.

Morevoer, there is evidence to show that the earth's figure is still more irregular than that of a peg-top.* Sir John Herschel, although taking the astronomical side in the controversy, aptly stated the facts in the statement that " the earth is earth-shaped." Listing's name of geoid, which expresses this view, has now supplanted the old oblate spheroid from everything except the text-books. That there are local deformations in the earth's shape is demonstrated by the differences between the astronomical and trigonometrical determination of positions. Places have two different longitudes, the astronomical longitude obtained by astronomical observations, and geodetic longitudes determined by terrestrial measurements; the differences are often considerable. It was calculated, *e.g.*, that the trigonometrical and astronomical determinations of the stations used in the delimination of the Canadian and United States frontier should have agreed within 40 feet, or 0.4 of a second of arc; but the average error was more than five times as great, and ran up to eighteen times as much as it should have been.

Astronomical determinations, moreover, are often not only inconsistent with geographical measurements, but they are often inconsistent with themselves. For example, one of the most refined estimations of longitude that have yet been attempted, is the series undertaken by the "K. K. topographische-militar Institut" of Vienna. To ensure accuracy during these observations, the most elaborate precautions were taken. Corrections were even made for the effect of the doses of quinine which the astronomers took when working in malarial climates. In one of the series of observations, the difference in longitude between Vienna and Milan was determined first directly, and then by determining the difference between Vienna and Brescia and that between Brescia and Milan. But in spite of all the care, the results did not tally. The sum of the two differences was not the same as the single difference. The whole, in fact, in this case was less than the sum of its parts.

To astronomers it may seem an unnecessary waste of time to devote so much to proving these deformations from the "spheroid of reference." But as the idea is less familiar to geographers and geologists, the insistence on this deformation may not be useless. It may be worth while adding a quotation from Prof. C. A. Young,[*] to show that the spheroid of reference is only a convenient assumption. "On the whole," says Prof. Young, "astronomers are disposed to take the ground that since no regular geometrical solid whatsoever can *absolutely* represent the form of the earth, we may as well assume a regular spheroid for the standard surface, and consider all variations from it as local phenomena, like hills and valleys."

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* As Prof. Darwin suggests, potato-shaped would be a more correct simile.

As deviations from the assumed spheroid of reference exist, it remains to inquire whether there is any evidence that they agree in position and arrangement with the theory of the tetrahedral deformation of the lithosphere.

The evidence already quoted of the dissimilarity between the northern and southern hemispheres and the elongation of the latter, is geodetic proof of the northern flattening and the antarctic projection, *i. e.,* of one face and one tetrahedral corner.

The three flattened lateral faces and three projecting vertical edges are sufficiently demonstrated by the three great oceans and the land-lines that have divided them. Practically, all the theories agree upon that point. It is well known that gravity is greater than was expected at most oceanic islands. Lallemand and de Lapparent have suggested that this is due to those islands being below the level of the ordinarily accepted figure of the earth, and therefore nearer the earth's centre of gravity.[†] Fisher has suggested that the Pacific ocean is the hollow left by the loss of the material which forms the moon. Faye has explained the ocean basins and the greater density of the crust below them as due to more rapid refrigeration below the cold oceanic abysses. According, therefore, to Faye, the rocks below the oceans contracted more than those below the continents, became denser, and accordingly sank.

Thus from all points of view the three oceans represent areas of depression, and the three land-lines of South America, Africa, and Australia mark intervening projections. The oceans mark the low areas in the lithosphere as obviously as the bubble of a spirit-level marks its higher end; and they give, therefore, evidence of the triangular lateral flattening of the southern half of the globe.

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[*] C. A. YOUNG, General Astronomy,' p. 101. 1889.

[†] This explanation is inadequate, as it does not explain the deviation of the pendulum on coast-lines towards the ocean. The excess vertical attraction of the islands has been explained as due to the attraction of the mass of the island and its base.

But as, on the mathematical figure of the earth, such lateral flattening is more improbable than variations along the axis of rotation, let us consider whether there is any geodetic proof of these flattened faces and projecting edges.

There has been a long controversy as to whether Bessel's or Clark's ellipsoid better represents the figure of the earth. Clark's figure was the later in date, and is generally considered as the more exact. Helmert therefore expresses some surprise that the gravitational observations in central Europe along the 52d parallel of north latitude agree with Bessel's curve better than they do with Clark's; this is the case all across the area on which Bessel's work was done. But as soon as we get into the Volga basin, the gravity line diverges from Bessel's curve and approaches that of Clark. The change comes due north of the Eurafrican meridional edge. The anomalies are at once removed if we assume that both ellipsoids are locally correct; that Bessel's curve is true for Europe, and Clark's correct for Asia; and that the two merge into one another north of the line of the Eurafrican tetrahedral edge.

On the tetrahedral theory, there ought to be a projection north of this tetrahedral edge. And gravity determinations show a great deficiency in gravity in western Russia in an appropriate area along the Volga basin. It is true that the figures have been queried. There is a natural tendency to query all facts that do not agree with theory, and the notes of interrogation in this case may illustrate that tendency. But on the view that there is an upward deformation of the earth in this area, the anomalous deficiency in gravity observations is at once explained.

It may be replied that the existence of a normal gravity attraction at Moscow negatives the assumption of a superficial deformation; but the relative excess of attraction there is possibly due to the outcrop of Palæozoic rocks, of greater density than the loose sediments of the Russian lowlands.

Passing from Russia to the area in North America, where the next tetrahedral corner should occur, there is another area of deficient gravity, which may also be due to that area being a tetrahedral elevation. The deficiency is explained by the assumption of vast subterranean blocks of very light material. But that explanation is prohibited in the Russian case, since, as Helmert has shown, the deviations of a plumb-line from the vertical are inconsistent with the existence of such blocks. In reference to the North American case, Helmert has remarked that the light subterranean blocks must have descended for several kilometres; and Mildenhall has shown that no reasonable assumption will suffice to explain the facts.

It would be too much to claim that geodetical evidence at present available proves the tetrahedral theory, for accurate data are not yet available for a sufficient proportion of the earth to show whether the major deviations are based on a regular plan; but papers, such as that of Mr. E. D. Preston, show that geodesists are more inclined to regard the theory with favor. It is at least clear that geodesy does not disprove the hypothesis, and that some puzzling geodetic anomalies receive a simple solution if the theory be true.

GEOLOGY AND THE TETRAHEDRAL COIGNS AND EDGES.

Let us now turn to geology, to see if its evidence as to the past history of the world refutes or supports the theory.

The geological evidence ought to be of especial value, as we should expect to determine the position of the tetrahedral coigns on the face of the earth.*

If the tetrahedral theory be true, the four tetrahedral coigns should be areas of unusual stability and strength. Comparison of the three meridional land-belts shows that each of them begins in the north with a vast block of Archean rocks. The Eurafrican zone, in longitude 20° E, begins with a block occupying Scandinavia, Finland, and Lapland, which Suess has termed the "Scandinavian schild." It is an area of great geological antiquity, which has long remained above sea-level: bands of marine deposits of different ages sweep round it, but the block may never have been below sea-level. It has unquestionably remained as a solid impassive block, which has dominated the whole geological history of northern Europe. South of the Scandinavian coign are the transverse east and western chains of the Alps and the Atlas, with the Mediterranean trough between; and far to the south we have the old plateau of South Africa.

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* They were assigned to their geometrical positions by Green, and in the nteresting recent tetrahedral volcanic map of M. Michel-Levy.

Let us now go 120° westward to the American zone. It begins with another block of old Archean rocks, forming what Suess has called the "Canadian schild." It occupies Canada, Labrador, and most of Hudson bay and Baffin's Land, and underlies Greenland. Bands of marine deposits surround it, but it has perhaps never been itself below sealevel; its geological age, at any rate, is enormous. South of the North American coign we have again a pair of east-west mountain chains, forming the highlands of Cuba and Venezuela, separated by the Caribbean trough. This zone also ends southwards in an old plateau resting on Archean rocks.

The third meridional zone repeats the same characters. It begins with a block of Archean rocks, of which we may speak as the "Manchurian coign." South of this coign are the east and west ridges of Malaysia and the depressions parallel to them; and south of that, again, we have the Archean plateau of Australia.

The three main land axes of the world have remarkable resemblances in structure, and they present three equidistant blocks of great stability at the three tetrahedral corners. We may, therefore, speak of the "schild" as the three northern coigns or corner-stones of the earth.

The existence of these massive coigns* at the three tetrahedral corners has produced one point of divergence in the earth-plan from the geometrical figure of the tetrahedron. The existence of three such broad massive blocks naturally strengthens the line between them; and, as we have seen, the main divide in the northern hemisphere runs from coign to coign. The tetrahedral edges would naturally be lines of weakness and of movement; but in the northern hemisphere, the horizontal lines of yielding are deflected southward by the stability of the band supported by the earth's three northern coigns. Hence the great band of disturbances is subtropical, and runs from the Caribbean to the Mediterranean, across the Persian gulf and the Malaysian archipelago.

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* This suggestion of the word "coign" for "corner" I owe to Mr. L. Fletcher, to whom I am indebted for much helpful advice. The term is suitable, as it is used for a printer's wedge as well as for the corner-stone of a house.

In the case of the vertical edges, however, the agreement in position, as well as direction, is exact. Precisely below the three corner blocks, there are three lines of instability coinciding with the vertical tetrahedral edges. Below the Canadian coign there is the line of the Andes (long. 75°), which, according to some geologists is still undergoing elevation. Almost 120° east of the Andes, and below the Scandinavian coign, is the Erythrean rift-valley (mean long. 40°), in which some of the earth-movements are unquestionably of very recent date. Again, nearly 120° eastward, and due south of the Manchurian coign, is the recent line of movement represented by the eastern coast of Australia.

The main mountain systems of the world correspond, then, in direction or position, or in both, with the edges of the tetrahedron. The mountain lines run east and west in the northern hemisphere, and run meridionally in the southern hemisphere —that is, always parallel to the tetrahedral edges.

But it will be said there are three great exceptions, for the Ural mountains, the Appalachians, and the Rocky mountains are meridional instead of transverse, and that they therefore contradict the scheme. The contradiction is only apparent. The existing mountain ranges date from two main periods of mountain-building—the Upper Cainozoic and the Upper Palæozoic. The Upper Tertiary system includes the Alps, Andes, Himalaya, Pyrenees, Caucasus, and Atlas, etc. The Urals, Rocky mountains, and Appalachians belong to the Upper Palæozoic system. Before we can say whether these chains confirm or refute the tetrahedral theory, we must determine the distribution of land and water at the time when they were made.

Now, we know that in upperPalæozoic times one land fauna and flora ranged round the southern hemisphere from Australia to India, and thence to the Cape and South America. Instead of there having then been a continuous ocean-belt separating triangular points of land, there was then a southern land-belt, which was supported by three great equidistant corner-stones, the Archean blocks of South Africa, of Australia, and of Patagonia and the Patagonian platform.

What the south pole was doing then is hidden by our deplorable ignorance of that area: but there is evidence that to the south of this southern land-belt there was a cold, ice-laden sea.

Now let us consider the state of affairs in the arctic regions at the same period. At the present time the Mollusca of the Behring sea and North Atlantic belong to two essentially distinct faunas. But in upper Paleozoic-Triassic times, one fauna occupied both regions, and that fauna moreover extended uninterruptedly round the northern hemisphere, and apparently, along certain lines, extended some distance to the south. There was, in fact, a northern ocean-belt, which apparently surrounded a cold arctic land. The distribution of the land and water was then on the same plan as at present, but with land and water exactly reversed. There were two opposite interlocking belts of land and sea, the former based on three Archean corner-stones, the latter projecting toward the equator between three Archean plateaux.

Thus the plan was the same as at present, but the conditions were reversed. This gives us the clue to the mountain chains of the same period. That also was a double system. There was a sub-tropical mountain girdle, the ruins of which we can trace right across the old world from eastern China to western Europe, where it is cut off by the Atlantic slope. And projecting meridionally from that equatorial girdle opposite the three troughs we have three mountain ranges running along the meridional ridges. These are the Ural mountains (60° E.) north of the eastern continuation of the South African trough, the Appalachians [illegible] north of the western part of the old Patagonian trough, and the [illegible] of Kamschatka [illegible] north of the trough of Australasia.

[illegible]

Such a change in the position of the [illegible] [illegible]

[illegible]

sequence of renewed contraction, the flattening may occur elsewhere.

This hypothesis of the alternation of periods of deformation with periods of spheroidal recovery is geologically useful, as it suggests an explanation of a certain periodicity in geological phenomena. For instance, the later half of Palæozoic time may have been a time of slow tetrahedral collapse, culminating in an instability which led to the great mountain movements which closed the Palæozoic; then followed a quiet period of slow restoration of the spheroidal form, causing the series of marine "transgressions" which are the dominant feature of the geological history of the Mesozoic era.

VERTICAL RANGE OF DEFORMATION.

Reluctance to admit the possibility of such changes is reduced when we recollect how insignificant are the differences in level, when compared with the size of the earth. The use of exaggerated diagrams leads to unconscious magnification of the extent of the polar flattening, and of the difference between the continental summits and the oceanic depths. The study of large-scale maps has been authoritatively recommended. The examination of true scale curves and outlines may help us to realize the actual conditions. The accompanying figure* shows a section of the earth's crust from Stromboli to Vesuvius. The thick black band represents the section cross the Mediterranean: the line *ab* marks the depth of the Atlantic; the upper curve shows where the surface would be if there were no polar flattening. The lowest line marks the depth of one-hundredth of the earth's radius. The thickness of this zone in comparison with the size of the earth is shown on Fig. 7, *b*, which is a sector of a circle, with the zone of *a* shown, reduced to its true relative size. The polar flattening is barely recognizable, and the difference between sea-bottom and mountain summit is marked only by variations in the thickness of a line.

The diagram illustrates the insignificance of the deformations required: and that crustal disturbance occurs much deeper than the layer with which the tetrahedral theory is concerned is shown by the fact that the estimated centre of origin of the Lisbon earthquake lies far below.

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* Based on Lingg's 'Erdpofil.'

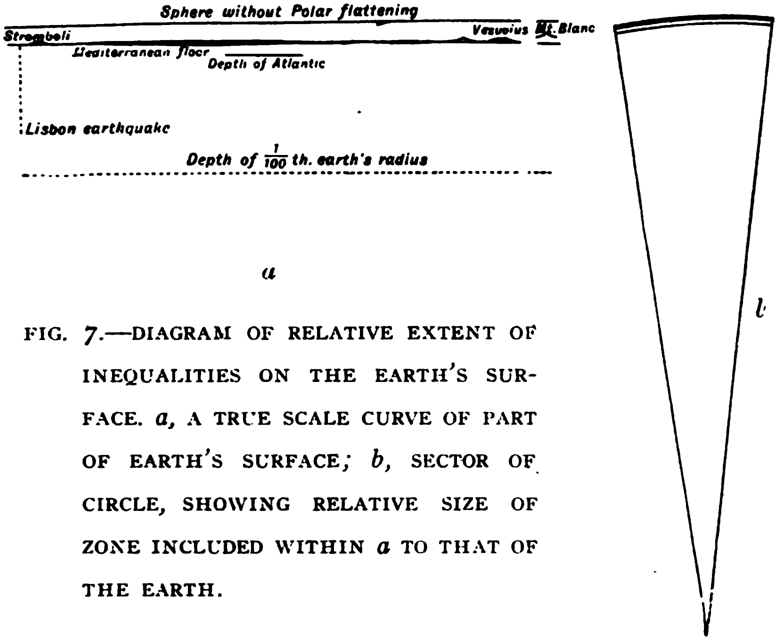

FIG. 7.—DIAGRAM OF RELATIVE EXTENT OF INEQUALITIES ON THE EARTH'S SURFACE. *a*, A TRUE SCALE CURVE OF PART OF EARTH'S SURFACE; *b*, SECTOR OF CIRCLE, SHOWING RELATIVE SIZE OF ZONE INCLUDED WITHIN *a* TO THAT OF THE EARTH.

This diagram also serves to show that the amount of contraction in the earth necessary to allow tetrahedral deformation is very small. This is important because, as Lord Kelvin has shown, the amount of contraction allowable during the later stages of the earth's history is very limited. But geologists have the authority of Prof. Darwin for accepting a certain amount of contraction. "A cooling celestial orb must contract by a perceptible fraction of its radius after it has consolidated," he tells us, and his considerations "only negative the hypothesis of any large contraction of the earth since the moon has existed."* And, unlike the contraction theory of the origin of mountain chains, the theory of the tetrahedral deformation of the lithosphere requires only a small amount of radial contraction.

Finally, it may be urged that even such deformation as the tetrahedral theory requires is impossible, since physicists have taught us that the earth is rigid. To this objection it is only necessary to reply that Lord Kelvin's rigidity argu-

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* *Phil. Trans.*, vol. 170, pp. 522, 523.

ments apply to the earth as a whole, and not to its crust; they deny the fluidity of the interior of the Earth, and do not pro- deny the fluidity of the interior of the earth, and do not pro- hibit any local deformations of the exterior crust. The once prevalent astronomical belief in the absolute invariability of the earth's shape and in the absolute fixity of is axis of rotation (expressed, *e.g.*, by Sir J. Herschel in 1862) no longer hinders progress. In fact, astronomers tell us that, instead of the absolute fixity of the pole, it now shifts its position to an appreciable extent under the influence of the movements of the atmosphere, the unequal melting of the polar ice, and by heavy falls of snow on the Siberian highlands. These movements of the pole are important, because they are taken to prove a certain elasticity in the earth. The movements demonstrated by actual observations are so far minute; but they at least allow geologists to say that, as such slight causes as those mentioned produce appreciable effects, more powerful causes acting for longer periods would work greater changes.

Summary.

The object of the paper is to show that the old belief in a definite plan of the earth is justified, since the distribution of land and water on the globe has been determined by the tetrahedral arrangement of the elevations and depressions in the surface of the lithosphere.

This tetrahedral plan is shown by the existence of (1) a northern land-belt, surrounding a northern ocean, and giving off three meridional land lines, which taper southward; (2) the southern ocean belt surrounding a south polar continent, and the three meridional oceans; (3) by the antipodal position of land and water; (4) by the course of the main watersheds and mountain chains.

It is held that this arrangement was not established in the earth's infancy, and therefore has to be attributed to some agency which has acted throughout geological history.

There are reasons for believing that a contracting sphere with a hard crust would undergo tetrahedral deformation, and the evidence of geodesy shows that the earth has been deformed from its spheroidal form. Its present figure may be defined as a geoid, which has been derived from a spheroid by irregular tetrahedroid deformation.

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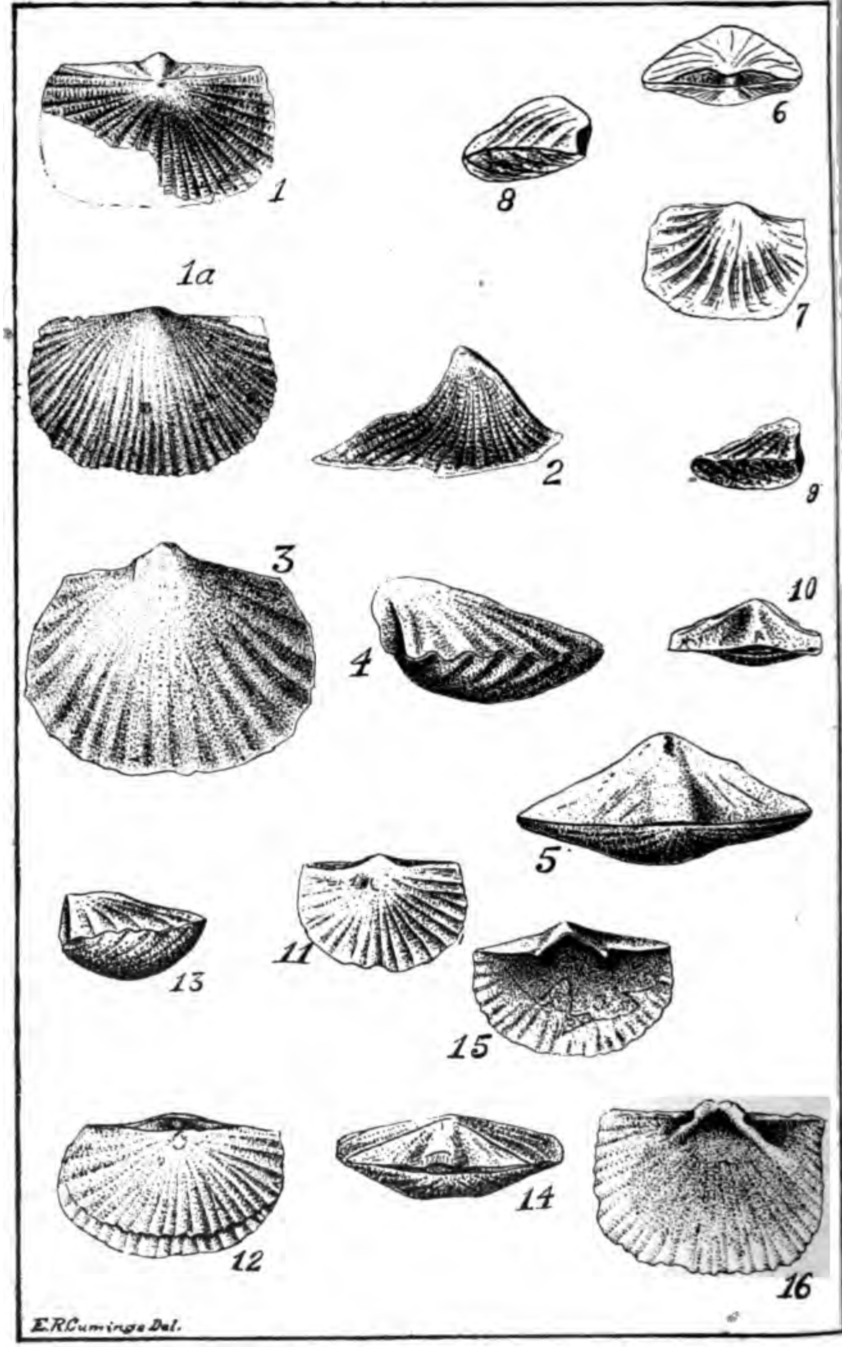
ASTOR, LENOX AND
TILDEN FOUNDATIONS.

PLATE XV.



E.R.Cumings Del.

ORTHOTHETES MINUTUS, N. SP. FROM THE SALEM LIMESTONE.

If such tetrahedral collapse be granted in the case of the earth, then the existing arrangement of oceans and continents receives a natural explanation.

The changes in the distribution of land and seas in the past may be explained as due to the conflict of two opposing forces, collapse caused by the earth's contraction producing deformations, which are reduced by the effects of the earth's rotation. Geological history affords evidence of the alternation of periods of tetrahedral collapse and spheroidal recovery.

The plan of the earth may, in short, be attributed to the continual foundering of the earth's external shell, owing to the unceasing shrinkage of its internal mass.

ORTHOTHETES MINUTUS, N. SP. FROM THE SALEM* LIMESTONE OF HARRODSBURG, IND.

By E. R. Cummings, Bloomington, Ind.

Plate XV.

The specimens described in the present paper are from the abandoned quarry known as the Cleveland Stone Company's quarry located one mile north of Harrodsburg, Monroe county, Indiana. This quarry is in the Salem limestone, and the specimens come from the top layers of the quarry and also from near the summit of the formation. They are associated with abundant representatives of the entire Spergen hill fauna, and are so far as I can ascertain specifically identical with the forms from Spergen hill referred by Hall† to *Streptorhynchus* (*Orthis*) *umbraculum* Schlotheim.

DESCRIPTION OF PLATE XV.

Fig. 1. Ventral valve of a specimen 4.75 mm. broad.

Fig. 1a. Dorsal valve of a specimen 5.5 mm. broad by 4 mm. long.

Fig. 2. Profile view of a specimen 5 mm. long.

Figs. 3, 4, 5. Ventral, profile and cardinal views of a specimen 0.9 mm. broad and 0.6 mm. long.

Figs. 6, 7, 8. Three views of a specimen 2 mm. broad which has an abnormally convex ventral valve and an abnormally short area. Only one such specimen was found and it is possible that it may prove to belong to a distinct species.

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* The name *Salem* is suggested by the writer in a paper now in press in place of the name *Bedford* as applied to the oolitic limestone of Indiana, the latter name having been for many years preoccupied as the name of the Bedford shale of northeastern Ohio.

† *Trans. Alb. Inst.*, vol. iv, p. 12; *Indiana Geol. and Nat. Hist.*, 12th Annual Rept., p. 325.

Figs. 9, 10, 11. Three views of a specimen 2 mm. broad.
Figs. 12, 13, 14. Specimen 2.5 mm. broad.
Figs. 15 and 16. Ventral and dorsal interiors of two mature specimens.

DESCRIPTION OF SHELL.

Shell semi-ovate to subquadrate in old individuals; hinge-line usually less than the greatest width of the shell, especially in young individuals; cardinal extremities forming an obtuse, or sometimes a right angle with the lateral margins. Surface firmly plicated; plications increasing toward the margins by interstitial implantation. Crests of the plications crenulated by numerous equally spaced fine concentric lines.

Ventral valve concave, with a pronounced tendency to irregular growth about the beak. In mature individuals the beak becomes strongly retrorse and greatly elevated, equalling in hight one-half the length of the shell. Area well defined, flat, showing in well preserved specimens a low ridge on each side of the prominent deltidium and parallel with its margins. The younger specimens sometimes show a perforation of the apex of the deltidium.

Dorsal valve regularly convex, greatest elevation about one-third of the way from the beak to the front margin, though there is considerable variation in this respect in individuals of different age. Usually some flattening at the cardinal extremities. Area very narrow or scarcely at all conspicuous.

Interior of ventral valve showing rather prominent teeth which diverge widely. Cardinal process in the dorsal valve elevated, projecting somewhat beyond the hinge-line; notch shallow, the grooves on the posterior faces of the apophyses very faint.

Ratio of breadth to length of an average adult individual about as eleven to eight.

Observation. This form cannot be referred to the *O.* (*Terebratulites*) *umbraculum* of Schlotheim*, from which it differs in the less length of the hinge-line, fewer plications, greater proportionate elevation of the ventral beak which in the present species becomes strongly retrorse, and the subquadrate rather than semi-circular outline of the shell. The figures of Schlotheim's species also show a strongly quadrilobate cardinal process, while in the present species the notch is very shallow and the grooves are very faint. The species to some extent resemble *O. lens* from which it differs in the form of the cardinal process and the greater proportionate length of the latter species.

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* Schlotheim, Petrefk. I. 256, II. 67; Schmer, Brachiop. Der Eifel, 216, t. 38, fig. 2; t. 44, fig. 4; Bronn Lethæa, Geog. I. 361.

DEVELOPMENT. In the search for specimens of this rather rare species (about fifty specimens were found among several thousand of the commoner Spergen hill forms) a number of very young stages were obtained. While even the adult individuals share in the general stunting so characteristic of the entire Spergen hill fauna no complete specimen in the writer's collection having a length of more than 5 mm., nevertheless these larger individuals present the usual features of maturity.

The smallest individual observed has a length of 0.6 mm. and a breadth of 0.9 mm. In this specimen the ventral valve is roughly conical in shape, though slightly more convex toward the beak which projects conspicuously beyond the hinge-line and is very prominent. The surface shows eighteen plications at the margin as against forty in the largest individual observed, while the posterior third of the shell is without ornamentation except a few obscure concentric markings. The area is high and the large deltidium less sharply marked off from it than in the older individuals. The breadth at the hinge is conspicuously less than farther forward.

The dorsal valve has its greatest convexity at the center and is also smooth for a considerable distance from the beak. It shows no sign of an area.

Individuals of the length of 2 mm. have the area perpendicular to the plane of separation of the valves, and the ventral valve showing a slight convexity toward the front. The number of plications has increased from eighteen to twenty-two or twenty-three, and the region of greatest convexity in the dorsal valve has approached somewhat the beak. The youngest individual shows a marked conformity to the generalized type of brachiopod, as was found by Beecher and Clarke to be the case in the species of the Waldron fauna.*

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* *Memoirs of the New York State Museum*, vol. i., No. 1.

NOTES ON PETROLEUM IN CALIFORNIA.

PROF. E. W. CLAYPOLE, D.Sc., Pasadena, Cal.

The existence of petroleum in California has been known from very early times. The old Mission Fathers in the Spanish days made use of it, or rather of its solid residue after evaporation (usually natural), under the name of "brea," or asphaltum, for various purposes, chiefly for roofing. Many attempts have also been made during the past half century to refine it but from various causes they have all failed more or less completely until recently.

Prof. B. Silliman's report in 1865 was the earliest scientific statement concerning the Californian oils, and during the following fifteen years the attempt to establish a profitable industry were several times renewed. One of the causes of their failure was the nature of the materials which differed from that of the eastern oils, and presented problems not solved by eastern experience.

The memory of men not beyond middle life will easily supply illustrations of the wild craze that swept over Pennsylvania about 1865, when the desire to become suddenly rich was met by the opportunity as the two have seldom met before. The mad excitement that almost carried the sober Keystone state "off its legs," to speak figuratively, has perhaps not been equalled since the day of the "south sea bubble" in the lifetime of Robert Walpole. The narratives of both read in the present day more like fiction than the literal facts of history. In reality the facts surpass fiction.

But the craze passed in California as it passed in Pennsylvania and petroleum-getting has settled down into a steady industry. Less steady, it is true, than in Pennsylvania, because the ground is less investigated and consequently the element of chance is a larger factor in the problem than in the East. The conditions are less understood. Pennsylvanian experience is not necessarily or always useful in California. The high price of fuel on the Pacific coast renders profit attainable in places and among circumstances which would, in the Atlantic state, entail only loss. Consequently operators have been compelled to a large extent to exploit the new field under new conditions and are now beginning to eliminate the element of chance which so heavily hampered most of the early efforts.

GEOGRAPHY OF PETROLEUM IN CALIFORNIA.

Up to the present time the following so-called "oil-fields" have been proved and to a certain extent developed. Most of them are in the southern part of the state. That others will be discovered in the future we can scarcely doubt, and that before many years have gone by the present yield of petroleum will be largely increased, is equally certain.

The Newhall field was among the earliest to yield a profitable return to the investigators. As far back as 1875 a productive bore-hole was put down a few miles to the northwest of Newhall with the primitive appliance of a spring-pole and auger, from which a flow of oil was obtained at the trifling depth of thirty-five feet. This very moderate success so near the surface stimulated further effort and next year a standard outfit was obtained and another hole begun. This resulted in a greater success and as Col. Drake's first bore at Oil City set Venango county on fire, so this well in El Pico cañon kindled a blaze in California that has not yet died out. The well has been flowing uninterruptedly ever since and has yielded nearly two million barrels without at present showing any signs of failure.

Naturally such success stimulated further experiment and a large number of wells have been drilled in Pico and Elsmere cañons with varying individual success, but the result on the whole has led to the laying of a pipe line from the wells to the wharf at Ventura forty-four miles distant. Many miles of branch lines also run through the district.

The latest field developed in Los Angeles county is at Whittier, a few miles southeast of the city. Since 1896 work has been going on there continuously and successfully and it is now one of the most productive spots in southern California. Figures cannot be easily obtained and are not always exact, but from more than twenty wells is obtained an average yield of above 500 barrels, at least, daily. This is conveyed in a steel pipe to Los Metos station a distance of three miles.

The Puente hills extend from Los Angeles southeastward for about twenty-five miles. While scarcely equalling the records just given, yet the fifty or more wells drilled in this field have yielded a steady supply for more than a dozen years and are still pumped. Their total yield is estimated at not less than one and a half million barrels and one of the wells is reported to have given during its first year 50,000 barrels. The oil from this field, or rather the residuum after refining, goes by a pipe-line to the beet-sugar factory at Chino, sixteen miles away, which has used about 100,000 barrels a year.

Not until 1892 was any successful attempt made to develop the various oil indications in the city of Los Angeles. In that year a small well was drilled to the depth of a little more than 200 feet, and a yield of oil obtained which though slight, was a stimulus to greater undertakings during the following years until now in 1901 there are within the city limits 600 or 700 wells yielding nearly 1,200,000 barrels yearly. The total yield from the field since it was opened is reported between 7,000,000 and 8,000,000 million barrels but the annual production has fallen off since 1897. Wells have been bored too close together and the *sand* which is neither deep nor thick, shows signs of speedy exhaustion. The derricks stand thicker on the ground at Los Angeles than at almost any place in Pennsylvania.

Passing to the central part of the state we find the oil-field of Fresno county with Coalinga and Oil City as its two central points. Numerous attempts had been made to find petroleum before 1895 but only since that year has the region come into the list of California oil-fields. Its yield now cannot be less than 35,000 to 40,000 barrels monthly.

Not a few of the Coalinga wells are petroleum-geysers which spout oil for a few minutes and then rest until the gas again accumulates and develops pressure enough to force the oil to a hight of some feet above the ground. This oil is piped to the Southern Pacific railway.

South of Fresno in Kern county and near its chief town, Bakersfield, lies another of the California oil-fields. It is situated near the southern end of the great valley of California —the San Joaquin—and not far north of the point where the Sierra Nevada and the Coast range come together and throw the rampart of the Tehachapi around its southern end. In this nook in 1897 near Bakersfield, a shallow trial well was dug which yielded a considerable quantity of oil at the small depth of sixty feet. So striking a result immediately attracted attention and wells rapidly multiplied in number and increased in depth. The *sand* thickens to the north and west and is so reliable that few or no dry holes have been sunk in this field. The sand has been tested for about ten miles in one direction and on an average for a mile and a half in the other.

An unusual circumstance connected with the Kern county field is that the strata are almost undisturbed and few indications of oil are seen on the surface. The greatest depth of the *oil-sand* is about 1,000 feet but the average is much less. The quantity contained in the ground must be enormous, the *sand* being more than 300 feet thick and containing, by conservative estimate, ten to fifteen per cent of oil.

Ventura county was the first paying oil-field of California but until within the last twenty years the results were small. Then began a more thorough exploration and some wells exceeding 2,500 feet in depth were sunk in Adam cañon. There are at present more than three hundred wells in Ventura county, most of them productive, but on the whole their paying life is not long for in a year or two their yield by pumping falls below paying level. Some have started with 300 barrels daily and are already practically dry after yielding probably 100,000 to 150,000 barrels during their lifetime.

Summerland in Santa Barbara county is remarkable among oil-fields everywhere because the work is carried on partly under the sea. Not only are wells drilled close to the water but many are sunk from wharves run out into the ocean for the purpose. Of these very few disappoint reasonable expectations. Some of these marine bores have reached a depth of 800 feet penetrating two *oil-sands* and oil has sometimes leaked into holes dug on the beach to the depth of only six or eight feet. No one of them gives a great yield of oil. a few barrels a day being the average, but almost all are in a paying condition.

The view from the beach at Summerland is unique resembling no other in the world. Slender wharves of seemingly frail construction run out from the beach and are crossed by others like themselves so that the bay is a maze of timber work on which stand at short intervals the derricks of the oil-men. So close are they that it seems almost impossible for all to obtain oil, yet failures are rare.

Orange county to the south of Los Angeles can scarcely be said to have begun operations until 1896, but during the interval its experiments have been attended with very promising results and already a number of companies are busy in developing its resources. A pipe-line to the sea at San Pedro contributes in no slight degree to the success of the operation in this field.

Without going into too much detail for which this is not the place, the above named districts summarize the results of the exploration for petroleum in southern and central California. That other fields will be found is almost certain. San Diego is making great efforts on the southern line of the state but the results thus far are small.

The prospects in California are good and that the State has in her oil-fields a supply of mineral fuel, to her invaluable, is already obvious. The high prices of coal and wood have been a barrier, almost insuperable, in the way of her advance in manufactures, but with the removal of this she will be in a position to take a new start in the industrial race.

Already the railways are adopting the new fuel. With the aid of some of the many devices for burning it, which scarcely come within our province here, it is found more economical, clean and efficient at $1.25 or $1.50 a barrel than coal at $6.00 to $7.00 per ton. By experiment engineers have found that two or three barrels of crude oil will do the work of a ton of good coal without making smoke or ashes.

Other important advantages accruing from the use of oil will at once present themselves before the mind of an engineer in California, where conditions are very different from those of the eastern states.

The present consumption of crude oil for purposes of heating and steam raising is immense, but to state it in figures is impossible. It can, however, scarcely be put at less than a quarter of a million barrels yearly and this would be a moderate estimate.

As a general rule the California petroleum differs from that of Pennsylvania and Ohio etc., by having as its base or more solid portion, not paraffine but asphaltum. In the mode of "getting" it little difference exists between the two regions. Nor do the processes of refining differ to any important degree. But there are great and noteworthy differences between the products of the various fields. For example a part of the Newhall field yields an oil almost as clear as the refined coal-oil of Pennsylvania and fit for use in a lamp without refining. It is worth at least $4.00 a barrel at the wells. There is no difficulty in realizing the effect which the sinking of such a well yielding 100 barrels of the oil daily would have upon the local market. These are the famous oil-wells of the Placerita cañon. A heavy oil carrying a large amount of asphaltum is found in some parts of Kern county and perhaps not half a mile distant a lighter one more like some of the eastern oils. Most of the Californian oils however are dark and heavy and consequently yield a lower percentage of kerosene. The gravity varies from twelve or fifteen or even less in the Kern river and Santa Barbara districts to thirty and thirty-five at Puente and to fifty in some wells near Newhall.

OIL PRODUCTION OF CALIFORNIA.

[illegible]	12,000	barrels
[illegible]	40,552	
[illegible]	[illegible]	
[illegible]	[illegible]	
[illegible]	[illegible]	
[illegible]	[illegible]	
[illegible]	[illegible]	
[illegible]	[illegible]	
[illegible]	[illegible]	

[illegible]

zoic formations. The following table will illustrate this detail:

Stockton,	Quaternary.
Puente, Los Angeles, and Kern Co.	Pliocene.
Ventura, Los Angeles, Kern Co., Newhall.	Miocene.
Ventura, Fresno, Kern Co.	Eocene.
Colusa Co. and Sacramento Valley.	Cretaceous.

The *general* horizons only of the oil-bearing strata are here, represented. Minute details are not yet attainable, nor would it conduce to the clearness of the outline to crowd it with detail.

The oil-bearing strata are usually sandstones interlaminated with shale as in the East, and both often show traces of petroleum, but the accumulations are in the sandstones. Signs of disturbance also are visible in many places sometimes accompanied with some degree of metamorphism.

In considering this subject we should bear in mind the fact that the geomorphy of California indicates intense orogenic action at a very recent time. Strata of late Tertiary date are contorted and compressed that they stand vertical over large areas. The *final* elevation of the Sierra Nevada and Coast range is not apparently earlier than the Pliocene, perhaps even later. The proportion of living species among the fossil forms abundantly proves the recency of the strata. The energetic and extended volcanic action visible in so many places is evidenced by lavas so new that they have apparently only just cooled and are scarcely yet touched by erosion.

The Anticlinal Theory. The accuracy of the anticlinal theory of the accumulation of oil and gas, as developed by Prof. I. C. White, in Pennsylvania, has received abundant confirmation from California. In many of the fields the line of development on the surface clearly coincides with the anticlinal line underground, and even where the strata are very slightly disturbed exact data will probably reveal undulations of low angle or irregularities, such as those that govern the accumulations in many places in the east.

Where the anticlinal ridges can be traced they are in most cases relied upon as safe guides for extending the investigation.

might be inferred from a map the strike of the Cali- n anticlines is usually northwest and southeast or nearly lany of their ridges though of so recent formation have eroded and consequently their oil, or at least its more e portion, has escaped leaving either no residue or only rea' or asphalt to indicate its former presence.

iese facts supply a rational base for the belief that when rata are deeply covered, numerous yet unknown oil-fields e found that at present lie below the depth explored and ly be detected by systematic geological study and judi- exploration with the drill. The greater degree of erosion northern counties is also the probable explanation of the it limitation of the oil-fields to the south of the state. e same time we must recollect that holes more than or 1,500 feet in depth are almost unknown.

ture and use of the oil. Probability scarcely indicates alifornian petroleum can compete with the Pennsylvanian ct as a source of illuminating oil. It more resembles the an and the Ohio and Indiana petroleum in this respect. s already mentioned its great value to the State will be el value. Where the lighter grades are produced the nating ingredients will doubtless be distilled off and the e will then be of equal or greater value as fuel. This is ly done. The heavy oils will however find their value se in taking the place of coal and supplying heat in many where the cost of coal would be an insuperable barrier. ower price of oil, its transportation by pipes, its supply furnace by gravity, the absence or slightness of the and ash, the avoidance of stoking, all these are advan- which cannot be over estimated in a comparison of the uels. To say that the exploitation of petroleum has California an open door where before it seemed hope- closed, is not an exaggeration of the fact or too roseate ure of the prospect.

e Future. It is too soon of course to prophesy the by predicting the duration of the supply. But in spite anticipation of a speedy failure, the eastern yield has t run out. It has continued beyond most calculations or ostications made forty years ago and there is even now nable ground for expecting early exhaustion. Nor is there any reason for hoping less in California. That the supply is finite is of course undeniable, but though finite it is so vast that the present generation and perhaps one or two more that will come after it may be enriched by this wonderful fund of latent power stored in the distant Tertiary era from the remains of Tertiary life.

The California conditions, moreover, render many wells which in the East would be useless, because unprofitable, sources of profit to their owners. Wells yielding one barrel of oil daily would scarcely be valued in Pennsylvania but here they are, to say the least, quite above the line of "no profit." The initial cost is small often not above $200 or $300, and the pumping can be done at a price not exceeding fifty cents daily, while the price is seldom below and often above one dollar at the well. If the bore is deeper and the cost therefore higher the oil obtained will probably be lighter and consequently of greater value in the market.

The duration of the individual wells also is not very different from that expected in Pennsylvania. Some have been pumped for twenty years and still are yielding a paying amount of oil. There is, therefore, no more ground for distrusting the duration of the Californian wells than there was thirty years ago for distrusting those of Pennsylvania.

Besides the kerosene produced from the crude petroleum a large quantity of lubricating oil is obtained occasionally in a pure form, otherwise by distillation. Then there is the asphaltum base of the oil, either left after the lighter portions have been distilled off or found in beds in the earth—the produce of natural distillation. At first an annoyance as a byproduct and a waste, tending to cause smoke on burning the kerosene, it is now one of the valuable products of the refinery. Masses of it are even thrown up on the beach in some places—the product of petroleum escaping from the sea-bottom. Elsewhere, as at Obispe, near Terminal island, huge masses of this mineral are quarried in the cliff, as rock, refined and sent abroad and to the eastern states chiefly for paving purposes. It occurs in disjointed and contorted strata or seams, often many feet thick and in quantity can be compared only with the great pitch deposits on the south American continent or the lake of Trinidad. It is sent largely to the eastern states where it is sold at a good profit. Being a solid it canot be passed through pipes but a very ingenious device has been recently adopted to transmit it. The asphaltum is dissolved in naptha and in this condition of solution passed through the pipe-line from the mines of Santa Barbara county to the coast where the naptha is evaporated and sent back for another load of asphaltum.

Little has been said here about the gas that accompanies the petroleum, though its quantity and value are large, because it has not yet come extensively into use as an illuminant. Unfortunately the wells where the gas pressure is greatest are usually far removed from cities and sufficient confidence is not yet felt in its persistence to warrant the laying of pipes to carry this most valuable and convenient fuel from the place of production to the place of consumption. Should its flow continue and increase there is no doubt that the day of its utilization will soon arrive. As yet, however, no Murraysville or Grapeville or New Washington has been evolved in California.

Since the above paper was written news has come from Texas of a discovery of petroleum which may fairly be compared with some of the greatest on record. At Beaumont, near the mouth of the Nachet, a tributary of the Sabine river, a bore-hole was drilled with the intention of experimenting but apparently without any very strong confidence in the result.

Allowing for considerable exaggeration in the early reports, we cannot doubt that a new and important factor has come into the problem and one which may have great consequences. It must equal most of the great gushers even if it fall far short of the 25,000 barrels a day first reported. From a six-inch hole the oil is said to jet to the hight of 200 feet.

For four days the flow continued and to check it was impossible. Before this was at last accomplished it was estimated that 150,000 barrels had flowed out much of which had been saved in hastily constructed earthen tanks. The well has been since reported to yield 8,000 barrels daily. It is only twenty miles from the coast.

Later still comes a similar report from the older oil-field of Indiana which, though on a rather smaller scale indicates that the days of "oil-strikes" have not yet altogether gone by.

SOME SALIENT FEATURES IN THE GEOLOGY OF ARIZONA WITH EVIDENCES OF SHALLOW SEAS IN PALEOZOIC TIME.

By WILLIAM P. BLAKE, Tucson, Arizona.

The geology of the northern portion of the territory of Arizona including the grand cañon and the plateau region has been studied and mapped by Powell, Dutton and others of the U. S. Geological Survey. Blandy has published some papers relating to central Arizona; the writer has contributed some special papers and desultory notes in reports to the governors of the territory and elsewhere, but in regard to the country south of the great plateau region very little systematized information has yet appeared in print.* An explanation may be found in the fact that the region is vast and difficult of access and until recently has largely been under the domination of the savage Apache.

Capt. Dutton in his monograph upon the Tertiary history of the grand cañon district, frequently refers to an unknown "Arizona Land." In this he shows a mental reaching out for far off shores from which a portion, at least, of the mighty mass of sandy sediment in the basin of the Colorado could have been derived.

Investigations in southern Arizona sustain the idea of the former existence of such shores, not perhaps as continental margins but as island ridges; crests of submerged mountain ranges rising at intervals above the waves of shallow seas. and with a trend or direction corresponding essentially to the trend of the mountain ranges of the region.

A cross-section of the territory in a northeast direction from the head of the gulf of California, the sea of Cortez, to the line of New Mexico, a distance of nearly 350 miles shows a succession of mountain ranges separated by long trough-like valleys often broad plains or mesas. There are some fifteen such main lines or axes of elevation with a general northwest and southeast trend. Commencing first at the gulf we have in succession the Gila range; Mohawk and Castle Dome; Growler Ajo; Maricopa, and Quijotoa, Baboquirari; Tucson, Santa Catalina, and Rincons, (extending northward to the Bradshaw group of elevations), the Santa Ritas (east of the valley of the Santa Cruz), the Huachucas and Whetstones; the Dragoons and Mule mountains (Tombstone), extending north into the Galiuro; the Pinaleno and Chiricahua, the Piloncillos east of the San Simon plains; ending with the Natanes and Prieto plateau and the Four Peak mountains.

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* Since this paper was written a memoir has been published by DR. THEO. B. COMSTOCK, in the *Transactions of the Am. Inst. Mining Engineers*, entitled "The Geology and Vein Phenomena of Arizona."

A partial bibliography of contributions to the Geology of Arizona may be found in *Bulletin No. 127 of the U. S. Geol. Sur.* and also in the *Report of the Governor of Arizona for 1899.*

These several mountain ranges may be considered as successive axes of uplift, or structure, with well-defined occurences of Palæozoic strata, generally resting upon a foundation of granite and Archæan gneiss. Regular anticlines and synclines are rare. Monoclines are the rule, as for example in the Huachucas and Santa Ritas.

The presence in all these ranges of massive strata of quartzyte, and frequently of coarse conglomerates referable in age to the Paleozoic, or earlier, bears conclusive testimony to the existence of shore-lines and of shallow seas in that early period of continent making. But there are also deep sea lime-stone of Devonian and Lower Carboniferous age and other limestones probably Silurian.

Coal Measures. In the Chiricahua mountains we also find evidences of Coal Measures and vegetation of that period in the shales and uplifted beds of graphitic anthracite several feet thick. So, also, in the San Carlos region, and northwards, heavy strata of the Carboniferous occur with seams of coal, but so far as yet determined of limited thickness and value. These occurrences are, however, sufficient to show a far western extension of the vegetation of the Carboniferous and consequently the existence of dry or swamp land at that time. The most western point in the latitude of Arizona at which Coal Measures have before been found was in the Rocky mountains near Santa Fe.* Thickly bedded limestones of dark color and of Carboniferous age occur in the mountains west of Tucson. The limestones in the Quijotoa mountains at the Vekol lead-silver mines contain an abundance of cyathophylloid corals and are referred to the Carboniferous. The dark colored limestones of the Mule mountains, at Tombstone,* and also those at the American mine in the Swisshelms are similarly referred, and are doubtless a part of the extensive series of limestone and shaly beds of the northern portion of the Santa Ritas; and a portion of the strata of the Whetstone range and of the Dragoons, and of the Galiuro mountains are of the Carboniferous age.

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* In 1857 I collected fossil ferns near Santa Fe which the late MR. LESQUEREUX identified as specifically the same as several species found in the Pennsylvania coal measures. PROF. DANA, in his fourth and last edition *Maunal of Geology*, p. 658, says "A Carboniferous formation without coal is the great fact for the western half of the continent," a statement which in the light of the above facts needs some modification.

Cambrian. Most of the outcrops of massive quartzyte uplifted and in contact with granite at several distant places are referred with some hesitation to the Cambrian. Such outcrops are found from western Sonora in nearly all the chief uplifts as far east as the Chiricahuas. In northern Sonora near the boundary line in nearly the southeastern continuation of the Gila and Mohawk uplifts, a well defined ancient quartzyte stands in vertical beds alongside of an intrusive granite. This quartzyte is marked by perforations like those of the Potsdam and probably properly referable to *Scolithus.* Conglomerates and quartzytes occur in the Buboquirasi range and in the Tucson mountains where there is a great thickness of strata in regular folds, probably representing a large part of the Palæozoic. Massive conglomerates with thoroughly rounded pebbles firmly cemented together occur near the source of the Cañada de Oro in the northern part of the Santa Catalina mountains; also at the American Flag rancho in the same mountain range. We again find coarse conglomerate opposite the mouth of the Arirapa near the site of old Fort Grant where quartzytes also occur resting on granite. Thickly bedded conglomerates occur over wide areas south of Tucson in the region of Ariraca and again in the northern portion of the Chiricahuas. It is not at present possible to correlate all these occurrences which no doubt represent different horizons, but they are all believed to be Palæozoic, or older. They bear united testimony to the former existence of shore-lines and rapid currents.

Beginning of Arizona Land. The Santa Catalina, Rincon, and Rillito group may be regarded as the northwestern extension of the great mass of mountains in central Arizona generally known as the Bradshaws. All these mountain ranges consist largely of granitic, gneissic, and schistose rocks of pre-Cambrian age with a highly complex folded structure, and exhibiting a high degree of meta-morphism. Taken together, these mountains may be regarded as the main axis of ancient uplift, and of insular land areas in the pre-Cambrian and Palæozoic periods, the beginning of the "Arizona Land."

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* See my paper on the Geology and Veins of Tombstone, *Trans. Am. Inst. Min. Engrs.*, X, 334.

Gneiss. The gneiss of the southern side of the Santa Catalina near Tucson is regarded as Archæan. It is remarkable for its regularity of stratification and its great thickness, probably over 10,000 feet. It occurs in great tabular masses made up of thin layers which when seen laterally give the appearance of evenly stratified shales and sandstones. The beds are, however, essentially granitic with the feldspar spread in nodules which make protuberances on the cleavage surfaces of the rock, and thus form a porphyritic or augen-gneiss rock.

Sheets or veins of granite are common in this gneiss. It is remarkable that this rock has such an even tabular structure without plication, wrinkling or folding and that it rests at a low angle generally not exceeding twenty degrees upon the massive nucleus of the Catalinas dipping southward and passing under the modern detrital accumulations, or "wash", from the mountains. These beds rise nearly to the summit of the Catalinas and then break off precipitously forming a line of cliffs facing the central part of the range. Some obscure traces of an anticlinal fold are visible on the western side.

Huronian or Arizonan. In the same range, but on the northeastern side, facing the valley of the San Pedro, another formation of thinly bedded and highly crumpled mica schist in sharply defined zig-zag folds is referred to the Huronian. This is the formation to which I have given the name Arizonan. Still further north occur the heavy conglomerates, red beds, quartzytes and limestones in which last corals referable to the Devonian occur. A section carefully measured in detail made here may be generalized as earthy limestone in thin layers with sandstone and quartzyte at the base. The strata dip eastwardly at a low angle. Their exact stratigraphic relation to the underlying red shales and sandstones has not been satisfactorily determined.

Devonian. Near Greaterville in Prince county on the eastern side of the Santa Rita mountains I have found a locality of Devonian fossils in limestone, and have collected *Spirifer hungerfordi, Atrypa recticularis Bellerophon* and the coral *Acervularia davidsoni,* besides others not yet determined.* These occur in a massive bed of light colored limestone standing nearly on edge contiguous to a thick stratum of limestone conglomerate made up of rounded pebbles of limestone, unquestionably derived from some older beds.

In the Box cañon which cuts through this mountain from east to west there is a remarkably interesting section. Resting upon a coarse porphyritic granite at the western side we find in nearly vertical attitude a pebbly conglomerate overlaid by quartzyte and this in turn by a thick series of red shales probably over 1,000 feet thick. At the eastern end a last exposure ot this section, the fossiliferous limestone, the equivalent of that at Greaterville and like it, accompanied by the calcareous conglomerate, crops out in such a way as to render its relation to the red shales obscure. There is seemingly a break and want of conformity as at the Catalina section farther north.

Faulting. There have been great faultings and displacements over the entire area of Arizona, notably along the valley of the San Pedro northwest and northeast.† In the Huachuca mountains on the western side of this valley the dominant characteristic section is a very heavy regularly stratified quartzyte surmounted by limestone and resting upon porphyritic granite and presenting bold escarpments towards the east. In the section of these mountains thick beds of red shales are found like those of the Santa Ritas, while higher in the range there are massive strata of limestone conglomerate apparently not conformable with the red shales. This conglomerate appears to be the equivalent of that found in close association with the Devonian limestone of Greaterville.

Silurian and Cambrian. We are without evidence by fossils of the existence of Silurian terranes, but the identification of a

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* In the identification of the species mentioned I have had the assistance of Prof. C. E. Beecher of the Peabody Museum, Yale University.

† Such faultings have been noted and described by Dr. Comstock.

Devonian horizon permits us to believe that we have representatives of the Silurian and Cambrian in the underlying strata. The relation of the Devonian limestones to the sub-jacent beds is under investigation. It is believed that representatives of the Silurian and Cambrian systems will be found and that in the basal quartzytes and conglomerates we have Cambrian beds.

Extensive outcrops of fine-grained mica and clay slates are found in the Dragoon uplift north of Russellville, and beyond northward.

A region in the eastern part of the territory covered by the White mountain Indian reservation is as yet but little known.

Crystalline Rocks. The underlying foundation rock in southern Arizona is a coarse-grained porphyritic granite which much resembles the typical granite of Belihen in the Vosges.* This granite is found in the Santa Ritas, in the Huachucas at Guma, and at and beyond Oracle at the north end of the Santa Catalina uplift. Here it extends northward to Mammoth and beyond towards Riverside, the Superstition mountains and Salt river east of Florence. It underlies the tufas and lavas at Gila buttes at the head of the Florence canal. It presents generally a broad apparently eroded surface and here and there includes belts and portions of fragmentary rocks, quartzytes, and limestones, as for example in the Gold Field region east of Mesa and on the road from Tucson to Oracle. Large areas of granite exist in the Bradshaw mountains, notably at and around Prescott. These are granite which weather into fine large bowlders of decomposition at Peeple's Valley, Yarapai county; at points north of Phœnix, at Tombstone and other localities notably north of Dragoon Summit near the Wolfram veins. Plutonic intrusions in the form of dykes abound both in the crystalline and fragmentary formations. Distinct local metamorphism is common where dikes of porphyry cut through limestone with the production of bordering masses of garnet rock often penetrated by copper sulphide.

A large extinct volcano, Pinacate, rises just below the southern border near the head of the gulf of California, but it is not comparable in magnitude and grandeur with San Francisco mountain near Flagstaff and the neighboring cones dominating the plateau south of the grand cañon. Lava streams of compar-

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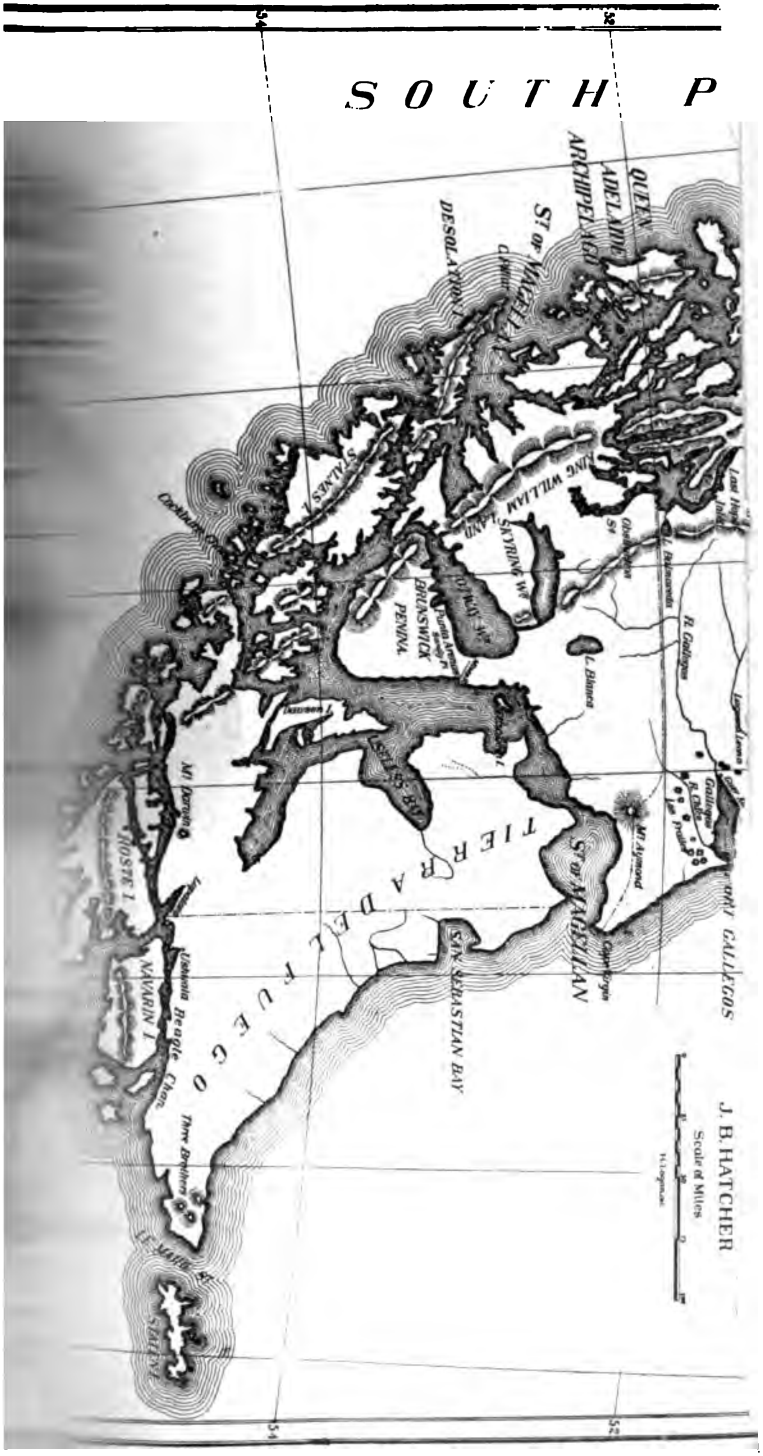
* Vide the series of typical rocks from Krantz of Bonn.

The northern of these two routes was the one traversed Lieut. Musters more than thirty years ago; while the south was chosen by Darwin, Moreno, and others. Few trav diverged far from either of these natural highways, so much of the interior of Patagonia remained a *terra incog* until quite recently. Within the last five years, however, knowledge of the interior of this country has been very gre increased. This has been accomplished chiefly by the expl tions of the Argentine and Chilian boundary commissions, su plemented, perhaps, by the expeditions conducted by the pre ent writer in southern Patagonia in behalf of Princeton University. To these explorations must be accredited the discovery of many new lakes, rivers, mountains, and other geographic features, as will at once become apparent by a comparison of the sketch map accompanying this paper with any of the older maps of the same region. This is especially true of that region lying between the Rio Santa Cruz and the forty-sixth parallel of south latitude.

It is not the purpose of the present paper to chronicle any of these discoveries, but rather to discuss the origin of some of the geographic features, and more especially of the lakes which, as will be seen by a glance at the accompanying map, constitute an important part of the physiography of this region.

The lakes of southern Patagonia may be divided according to their origin into three classes, viz.: *residual, glacial, and tectonic.* Of by far the greater importance are the lakes of tectonic origin. By referring to the map, an intricate series of lakes will be seen to extend in a line approximating that of the seventy-second meridian of west longitude throughout the entire length of the region under discussion. The exceedingly irregular outline of nearly all these bodies of water distinguishes them at once as true mountain lakes. Though the eastern extremities of many of them occupy lateral valleys that have been cut through the eastern range of the Andes and project well out into the great plain that extends from the mountains to the Atlantic, yet they one and all penetrate far to the westward, extending quite through the eastern foot-hills and sending out numerous arms and ramifications into that labyrinth of deep mountain gorges that separate the eastern lateral range of the southern Andes from the central and main range of the same mountain system.


SOUTH P
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QUEEN ADELAIDE ARCHIPELAGO
St OF MAGELLAN
DESOLATION I.
KING WILLIAM LAND
STAINES
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L. Blanca
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USELESS BAY
TIERRA DEL FUEGO
St OF MAGELLAN
Mt Aymond
Cape Virgins
GALLEGOS
SAN SEBASTIAN BAY
Mt Darwin
HOSTE I.
NAVARIN I.
Ushuaia
Beagle Chan.
Three Brothers
LE MAIRE St
STATEN I.
J. B. HATCHER
Scale of Miles

NEW YORK
UNIVERSITY

Many of these lakes, like Argentino, Viedma, San Martin, Pueyrredon, and Buenos Aires, are of large size, fifty to 100 miles in length, or even longer. None of them have as yet been fully explored and accurately charted. All of them are, except on their eastern shores, surrounded by lofty, precipitous mountains. The summits of the latter are covered with immense fields of snow and ice, from which descend glaciers that occasionally extend quite down the mountain slopes into the waters of the lakes. Huge blocks of ice are frequently detached from the front of such glaciers and float off into the lake as icebergs of no inconsiderable proportions.

The basins occupied by these lakes are largely of tectonic origin and they are chiefly due to the unequal folding of the strata that took place during the elevation of the southern Andes in late Tertiary times.*

With the exception of lakes Viedma and Argentino, this great series of lakes all discharge their waters into the Pacific, notwithstanding the fact that they lie entirely to the eastward of the main range of the Andes, and that the eastern extremities of most of them project even into the great plain of eastern Patagonia.

Just to the eastward of this series of lakes of tectonic origin and situated on the plains, entirely without the foot-hills of the Andes, there is a second series of lakes evidently of glacial origin. For the most part these lakes are of small size and of minor importance, though some of them, like Lagoona Blanca, lake Cardiel and lakes Colhue and Musters (the two latter are not shown on the accompanying map, since they lie somewhat beyond the forty-sixth parallel) are of considerable dimensions. These lakes have for the most part originated from the damming of preglacial drainage systems with glacial detritus during the recession of the glaciers that occupied these valleys at the close of the glacial period. Like the lakes just mentioned they contain fresh water. Although for the most part they have no surface outlet, the circulation permitted by the confining glacial drift is usually sufficient to keep the waters sweet, but a few of them do in very dry seasons become somewhat brackish.

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* For a further discussion of the origin of these lakes, see "Some Geographic Features of Southern Patagonia, with a Discussion of their Origin," by J. B. HATCHER: *Nat. Geogr. Mag.*, vol. xi, pp. 41-55.

Scattered all over the Patagonian plains from the strait of Magellan to Bahia Blanca are great numbers of salt lakes. Such lakes are usually of quite limited area and of exceedingly shallow depth, though they occasionally attain to considerable dimensions. In reference to their origin I have called these salt lakes *residual lakes*. I have elsewhere advanced the theory that these lakes have resulted from confined bodies of water, cut off from the sea, during the process of elevation, which began at the close of the Tertiary and which resulted in the final recovery of this region from the ocean. I have held that the salt of these lakes has been derived directly from sea water and has not resulted by evaporation from the surface of an originally fresh water lake with no outlet. No doubt some of the salt and other saline matter found in these lakes has been derived in this manner, but I believe that for the most part it has resulted directly from the evaporation of confined bodies of sea water. From the paleontologic and geologic evidences it is apparent that for a considerable period in late Tertiary times this region was elevated above the sea and subjected to erosion. During this period of late Tertiary elevation all the more important of the present drainage systems were outlined. Near the close of the Tertiary there was a subsidence just sufficient to permit the ingress of the sea. This submerged condition prevailed only for a relatively very short period, but sufficient for the deposition over the previously eroded surface of a thin layer of sedimentary rocks with characteristically marine fossils. At the close of the Tertiary a period of very gradual elevation set in, resulting in the final rescue of what is now southern Patagonia from the sea. As this land-mass gradually emerged, the higher table lands separating the previously eroded water courses would be the first to appear as islands and peninsulas separated by narrow channels and bays formed by the valleys of the drainage systems mentioned above. As the elevation continued the bottoms of such valleys would be successively brought above the water level and numerous small bays would be formed in all the smaller tributaries. Across the mouths of such bays bars would be thrown by the action of the tides. The formation of such bars, together with the gradual elevation constantly taking place, would tend to decrease the circulation between the waters of the bay and the ocean. By the combined action of these two agencies, the circulation would be more and more impeded until a stage would be reached in which this circulation would become intermittent. The two bodies of water would then be entirely separated, except during periods of unusually high tides, when the waters of the sea would rise sufficiently to overflow into the bay, or lake as it might now be more properly termed. At first the obstruction would not be so great but that the bi-weekly high tides occurring with each full and new moon would produce a flow of water from the sea into the lake, thereby replenishing every two weeks the water lost by surface evaporation with a new supply of sea-water. After a time the obstruction would become so great that only the exceptionally high semi-annual tides would suffice for its submergence, and the replenishing of the waters of the lake would then occur only once every six months. After this a stage would be reached when ordinary spring tides would no longer suffice, and only an exceptionally high tide brought on by a continued strong easterly wind, acting in conjunction with the sun and moon at the period of spring tide, would pile up the waters of the sea sufficiently high to overflow the isthmus separating it from the lake. Such conditions would, of course, occur only at irregular intervals and would constantly become less and less frequent, until finally all communication would cease and the smaller body of water would become entirely separated as an inland salt lake, gradually diminishing in area after the last overflow, by evaporation from its surface until a point would be reached when the loss by evaporation would just balance the gain from tributary streams and springs, which latter, in the lakes in the region now being considered is exceedingly slight.

It was during these stages of intermittent communication that the salt deposits were formed. These deposits are now found often covering the bottoms and adjacent shores of the lakes to a depth of several feet. During periods when communication between the lakes and the sea was suspended, the volume of water in the former would be greatly reduced by evaporation, thus increasing its salinity until an oversaturated solution would be attained, resulting in the precipitation of considerable quantities of salt. With the next ingress of the sea a fresh supply of salt would be introduced in solution, to be deposited in the same manner during the next period of suspended inter-communication. Such conditions, continued over a long period, have resulted in the deposition of the considerable bodies of salt now found in and about these lakes.

In the manner just described series of salt lakes were formed and may still be seen occupying slight depressions over the bottoms of all the abandoned water courses of Patagonia; while every stage in the process of the formation of such lakes may be observed in and about the heads of the different inlets all along the coast. Exceptional advantages for studying the origin of these salt lakes are offered at the head of the bay of San Julian and in the valley extending from the bay into the interior for a distance of 100 miles. In the bottom of this valley are numerous salt lakes, while in the region about the head of the bay there is a succession of lakes and inlets, showing every stage in the process of lake formation as detailed in the foregoing lines.

Dr. Otto Nördenskjold has taken exception to this theory of the origin of these salt lakes, holding that they are not residual lakes, and that the salt has not been derived directly from the sea as I have maintained. He holds that the salinity of these lakes is due to the fact that they have no outlets and that the salt has been derived, as in many other salt lakes in other countries, from the surrounding rocks by the tributary waters. To my mind there are two very conclusive arguments against this theory and in favor of that of considering these as residual lakes. *First:*—None of these lakes are fed by perennial streams, their supply of water being almost entirely limited to freshets due to occasional heavy showers, and to melting snow in the immediate vicinity, so that it is entirely made up of surface water and necessarily contains very little, if any, saline material. *Second:*—Those lakes found nearest the coast and whose connection with the sea has only just recently been completely closed, are found to contain quite as important salt deposits as others situated many miles inland where the connection with the sea has long been severed; thus showing that the amount of salt in the latter has not been appreciably increased during the long period that has elapsed since their final severance. These facts, together with the observations made illustrating the method of formation of these lakes about the heads of many of the inlets of Patagonia, lead me unhesitatingly to pronounce them residual in origin, and as having derived the beds of salt found in and about them almost entirely from the sea direct.

Of the three systems of lakes described above, the first, or those of tectonic origin, are in point of size of vastly more importance than either of the other two. When Patagonia is finally opened up to civilization and its many natural resources are fully recognized and taken advantage of, this superb series of magnificent mountain lakes will come to be more generally realized and appreciated. They will then, no doubt, achieve an importance and consideration commensurate with their exceptional size and beauty. Hitherto, owing to their inaccessibility, few indeed are those who have been enabled to see them; but, buried deep in the recesses of one of the most lofty and rugged mountain systems to be found anywhere on the surface of our earth, by those favored few they will ever be remembered as masterpieces of creative ingenuity. Extending from the barren lava beds and bleak, cheerless plains of the east through the forest-clad slopes of the foot-hills on into the remote and silent recesses of the central range of the Andes, whose summits, rising ever higher, are finally lost in immense fields of snow and ice, they present along their shores a greater variety of physiographic and geologic features than may be observed elsewhere in an equally limited area.

Of the three systems of lakes described above those of glacial origin are, perhaps, economically of the least importance of all. Yet, lying among the drumlins and terminal moraines of the ancient glaciers, where are now to be found the best pasture lands of the Patagonian plains region, they will become of ever increasing importance as these lands are more and more occupied for pastoral purposes.

The salt from the residual lakes will always supply the local demand for that useful article and permit also of the annual exportation of considerable quantities.

EDITORIAL COMMENT.

CROLL'S THEORY REDIVIVUS.

Glacialists will read with much interest the discussion of the climate of Mars by Mr. Percival Lowell, published in the Proceedings of the American Philosophical Society,* Philadelphia.

Twenty-five years ago, when Croll's theory was tested by an appeal to the testimony of Mars on the bearing of eccentricity on glaciation, it was because Mars presented appearances suggesting polar ice-caps, and because he is in eccentricity and tilt favorable to the application of Croll's theory. It was immediately discovered that Mars, on the assumption that other conditions were similar to those of the earth, afforded no support to that hypothesis. One pole showed as large a cap as the other. Eccentricity therefore did not seem to affect precipitation about the pole.

But since then the examination of the physical conditions of Mars has proceeded. It has been discovered that the assumption of similarity with the earth was a mistake, and that Mars presents the opposite of similarity with the earth, "and with the flight of the similar the cogency of the argument departs." In the light of this change Mr. Lowell re-opens the case and proceeds to discuss anew the bearing of the planet Mars on the hypothesis of Croll.

Accepting the suggestion of Sir William Herschel, that the white spots that appear on Mars about his poles, are due to accumulations of ice and snow, and noting that they increase alternatingly and diminish again "in a certain chronometric cadence," he confronts at once the theory that those spots are due rather to congealed carbonic acid, for carbonic acid in extreme cold not only assmues a solid form, but that form is as white and delicate as snow. He calls attention to the reluctance of carbonic-acid to remain in a liquid form. It passes almost immediately from a solid to a gas. There are, however, certain features that appear about the margins of those white caps that show rather plainly that they disintegrate as they shrink, giving rise to belts and bays of different color. These marginal features behave precisely as if they were affected by the variations of the seasons, and are hence due to changes of temperature, and are to be attributed to the same cause or causes that produce the increase and diminution of the white spots. Water is the only known substance that will remain in the form of liquid sufficiently long and in sufficient quantities to answer all the conditions. Certainly it will not be allowed to assume an ocean nor rivers of liquid carbonic acid.

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* Op. cit., vol. 39, Oct.-Dec., 1900.

> The state of things seems to be this: so soon as either cap begins to shrink, there proceeds to surround it a blue belt. The belt increases with the increased rate of diminution of the cap and decreases as that diminution falls off. Meanwhile it keeps pace with the cap, shrinking with it so as to always border its outer edge.
>
> It is difficult to conceive how anything could more conclusively proclaim itself the liquid product of the disintegration of the cap. This badge of blue ribbon seems to mark the substance as H_2O.

To this conclusion, however, there are two drawbacks. One consists in the less heat received by Mars from the sun, which, as compared with the earth, distance for distance, would be only a moiety, and would interfere with any assumption of H_2O in liquid state on Mars in such large quantity. The other is a thinner air at the surface than we know, and therefore the absence of a blanketing atmosphere to keep out the cold of space. But these objections are not fatal to the assumption that the liquid substance that follows the margin of the white cap consists of water.

In the first place the greater amount of clouds and vapor of water in the earth's atmosphere causes the earth to reject a far greater proportion of the sun's heat. Much of the sun's heat intercepted by the earth does not reach its surface, quite apart from what is necessarily reflected. But the Martian sky is clear from clouds, perpetually. "All the heat a pure sky permits to pass falls unhindered upon the soil. Thus receptivity makes up what distance denies."

Secondly, the earth's blanket consists not in its atmosphere, contrary to what has been thought, but in the watery vapor that it contains. This has been shown by Tyndall. He stated that on an average day in England the atmospheric vapor of water exerts a hundred times as much reaction against the sun, and hence against the cold of space, as the atmosphere itself. Mr. Lowell concludes that if one seventieth part of the Martian atmosphere is watery vapor, and the atmosphere one-seventh of our own at sea level, it may render as effective a covering as our own. While not affirming that this is the case, he notes simply "how little we need go out of our way in possibilities to furnish Mars with a sufficient covering."

After sufficiently showing that these phenomena on Mars are due to ice and snow about the poles, and to the production of water as the caps recede, Mr. Lowell notes some peculiarities by which they differ from the snow caps of the earth. In many respects they are comparable and similar, but ours have greater extension, reaching, in the northern hemisphere, in their maximum, southward to about the latitude of 45°, producing a snow-spot about 90° in diameter. It would thus appear to an outside observer. "In this we live and move and have our being for some four months, and it is at least a pregnant thought that to such an outsider the highest development of life upon our planet should seem thus for nearly half the year to have its existence within the polar cap." From this maximum our snow cap, as viewed from Mars, would appear to dwindle till, about two months after the summer solstice, it would measure only about 40° across. The southern cap, from incomplete data, seems to be larger than the northern, both at maximum and at minimum.

On Mars the northern snow cap has a maximum of 70°. about 53 of its own days after winter solstice. It recedes then to a minimum of 3° which occurs about the same time after the summer solstice, and it retains the minimum size some time. Comparing therefore the northern caps of the two planets, it is apparent that that of the earth is greater than that of Mars at each extreme. As to the maximum this happens in spite of the fact that the Martian year and therefore the Martian winter is nearly twice as long as our own.

Again the ratio between the maxima and minima on the earth are as five to one, while on Mars they are as 130 to one. "To the belief that Mars lacks warmth this comparison is calculated to give a shock of surprise."

A still more remarkable contrast exists. This is the difference in behavior of the two Martian caps. The southern cap is bigger than the northern in winter and smaller in summer. It surpasses it in accumulation and again in dissipation. This can be affirmed, although the data of observation on the northern maxima are not satisfactory.

As to the cause of these differences between the south polar cap and its counterpart on the north pole Mr. Lowell shows that, under the law of the radius vector, to which both gravitation and light, or heat, are amenable, eccentricity can have no effect; nor axial tilt, since that brings the two hemispheres in turn under the same though varying conditions—as variant for one as for the other.

"Not the amount of heat but the manner of its reception, then, is responsible for the differences we observe," between the maxima and minima of the Martian snow caps. The difference between the maxima is rationally attributed to the surpassing length of the Antarctic winter, which is 75 of our days longer than the northern. The total heat received from the sun by the two hemispheres is the same, but it is intensified in a short season in the northern. The contrast between the minima of these snow caps is not so easily explained. The southern snow cap is more reduced in its short summer than the northern in its longer summer. Mr. Lowell mentions two factors that spring from the planet itself which may account for this (a) The more intense diurnal heat of the southern summer provokes greater volumes of water during its prevalence, and this adds to the readiness with which the snow cap as a whole could shrink. (b) The cloudiness at night (for every day is perfectly clear) is increased by greater daily dissolution of the cap, and hence the proportion of watery vapor is increased in the southern latitudes of Mars during the summer months. This increased blanket conserves the heat of the day before so that the following day, and every following day, is reinforced by the greater proportion of conserved heat. The two conspire to waste the Antarctic snows more rapidly than the northern. It appears then that on Mars eccentricity has no tendency to form a northern ice-cap, or about the pole of that hemisphere that has its summer solstice near perihelion, but that the permanent accumulation there is actually less than at the south pole.

In transferring this argument to the earth we are confronted at once with a differing total amount of moisture and the presence of oceans. This involves greater precipitation, and the formation of a larger amount of winter ice. Mr. Lowell shows that under increasing precipitation the Antarctic minima increase, relatively to the Arctic, faster than the Arctic, and hence that they finally reach and surpass the Arctic minima. In other words with precipitation increased equally over the whole planet the size of the perpetual ice-cap over the southern pole would finally surpass that about the northern one. "Whereas, then, with moderate precipitation the hemisphere with the extremes of summer and winter climate would have the less perpetual ice of the two; with more precipitation the result would be reversed. * * * Thus a glacial period might be produced with us under the very same conditions which would bar it on Mars. It would come about in consequence of the eccentricity of the orbit, but not chiefly because of that eccentricity. Rather we may say, because of the amount of moisture capable of being manufactured. For were the moisture to fall below a definite amount, not only would no glacial period result, no matter what the eccentricity, but actually a sort of anti-glacial epoch would be brought about by that very same cause."

"Our survey of the Martian polar caps, then, leads us to some curious conclusions. It starts with apparent contradiction of Croll's theory to end in final confirmation of it. It comes to curse and stops to bless. But it does more. It shows that eccentricity of orbit by itself not only causes no universal glaciation, but actually produces, on occasion, the opposite result in more than offsetting by summer proximity what winter distance brings about. Eccentricity needs water, and a great store of it as handmaid before its glacial work can be accomplished. Could our earth but get rid of its oceans, we, too, might have temperate regions stretching to the poles."

The vast blue-green areas of Mars are interpreted as grassy plains or forests. They prevail in the southern hemisphere. They wax and wane with the season, slightly changing their color. The dark bands that cross them are perhaps channels filled with slow running water derived from the annual dissolution of the southern snow caps, wasting away toward the tropics.

The eccentricity of the southern snow cap, which is marked from maximum to minimum, is supposed to be due to a depressed area, rather than to elevated lands. In this depression the permanent ice accumulates in greatest quantity, and survives through the intense summer. N. H. W.

REVIEW OF RECENT GEOLOGICAL LITERATURE.

Contributions to the Tertiary Fauna of Florida. By WILLIAM HEALEY DALL, A. M.

Part V. of the Contributions to the Tertiary Fauna of Florida by professor Dall is at hand in Part V. vol III., of the Transactions of the Wagner Free Institute of Science of Philadelphia. The publication bears date December, 1900. The present contribution deals with the Teleodesmacea: Solen to Diplodonta, and is a continuation of the work on the Tertiary fauna appearing in the previously issued publications of the Institute. It was found impossible to complete the discussion of the large family Veneridæ for publication in its appropriate place in the present part of the volume, and so it is deferred till the publication of the next part which it is believed will contain all that remains to be written to finish the subject. Some work on the Tertiary shells of Florida was published in volume I of the Transactions of the Institute, but it remained for professor Dall, in volume III. to take up the study of this most prolific and interesting fauna with a thoroughness that could not previously have been attempted. The fact that there are nearly 140 new species in the present part will give some idea of the practical newness of the field which professor Dall has so successfully cultivated, and of how little was really known about it when the author began his studies. Every such thorough-going contribution, dealing exhaustively with a single fauna, marks a real advance; it brings a whole new field within the known province of Paleontological science.

S. C.

Geology of the Boston Basin; vol. 1 part III. The Blue Hills Complex; by WILLIAM O. CROSBY. (Occ. papers, Bos. Soc. Nat. Hist.; pp. 289-964, pls. 15-39, No. 4, 1900.)

This paper completes the detailed study of the southern edge of the basin, carried on so long and well by Prof Crosby, from the Atlantic coast west to the valley of the Neponset. The author defines the complex as "the area of granitic and associated Cambrian strata which includes the Blue Hills proper, and extends thence eastward across Quincy and the northern parts of Braintree and Weymouth." It is a distinct geological unit.

The Cambrian strata occur largely on the north and south margins of the area, and consist of fine, poorly bedded slates, which are thought to have been deposited in a quiet area of some depth, one shore of which was perhaps to the northwest. The base of these slates is nowhere exposed. Prof. Crosby believes, although upon what data is not made clear, that the quartzytes northwest of the basin and the limestones of Shoreham and Newbury are lower Cambrian; and from that time continuous deposition occurred, through the middle Cambrian and a now denuded upper Cambrian series. Probably, also, sedimentation was prolonged through the Ordovician, and the detritus has since been removed.

Not later than early Devonian time the strata had been sharply folded, and were intruded by an igneous series almost entirely acid. The theory advanced for its origin is melting of the base of the slates, due to the blanketing effect of prolonged deposition; and formng an acid magma above the abyssal basic one. No estimate of the thickness of this stratified cloak is given; but to produce the existing effect there would be required a depth of sediment far greater than we have any warrant for inferring, and especially, such view seems inconsistent with the almost surface character of the igneous mass, not only near its summit but far down the sides, as exhibited in the aporhyolytes. It is much more probable that the intrusion burst through the base of the Cambrian series

In cooling, the batholith became differentiated both in texture and composition, being finer and more basic toward the periphery. For explaining the latter, the author uses Becker's theory of fractional crystallization. The results are two types of granites, biotitic and hornblendic, forming the main mass; and at the margins three phases, dioryte, fine granite, and aporhyolyte, the last grading into the granite. The later stages of refrigeration were apparently accompanied by further dike intrusion of granite, and dikes and flows of aporhyolyte.

The Carboniferous sediments, which make up a large part of the present basin, are thought to be really one formation, deposited delta-like, during slight oscillations; and while coal was being deposited elsewhere, the bottom here was too deep. This last conclusion is not borne out by the fossils discovered recently by Messrs. Burr and Burke; nor by the large amount of coarse sediment present, much of which can be proved to have traveled but a short distance. Very likely the reason is to be sought rather in the almost open-coast conditions, by which the sea action was too rigorous. The melaphyr, which is so characteristic of the southern part of the basin, is considered as a series of contemporaneous flows, and never intrusive. It may be pardoned, perhaps, if some students of the region still regard the evidence as pointing to intrusion.

The Appalachian revolution gave the present structure to the basin as a whole, which, however, then extended far beyond its present limits. The larger faults, particularly on the margin, result each from two disturbances—one during the deposition of the Carboniferous sediments, the later at the close, during the general orogenic action. The result, according to Prof. Crosby's interpretation, is a *graben* of sediments between two crystalline walls.

As far as know, the region has been above sea level since Carboniferous times, except during a portion of the Pleistocene. Erosion has removed the strata on either side of the graben, and much of the complex and basin. The granite has proved less resistent than the aporhyolyte, and the slate than either. The Blue

Hills mark the level of the Cretaceous peneplain, dominant farther inland. Below this is a "coastal peneplain," which rises westward and bevels off the earlier and higher level. Below this, again, is the basin. The discussion of the surface geology presents nothing new, in the chief author's part. This is followed by a paper entltled "Lake Bouvé, an extinct glacial lake in the southern part of the Boston Basin," by Dr. A. W. Grabau. An entirely separate chapter closes the work, on the "Palæontology of the Cambrian terranes of the Boston Basin," also by Dr. Grabau. Both papers are full, containing new material as well as a summary of existing knowledge; and they should be reviewed separately.

Altogether, this third part of the Boston Basin papers is a notable contribution on a difficult field; and shows most pains-taking labor. It is much to be regretted that the society has not completed its publication by issuing the geological map of the area which, the text states, accompanies the report. Also, the great care shown in gathering the field details does not appear to have been extended to all parts of the make-up of the paper. There is neither table of contents nor index, nor list of illustrations; nor is there any reference in the title to the two important contributions of Dr. Grabau. More summaries scattered through the work would prove a help, and the igneous part suffers much from almost an absence of chemical analysis. In places, too, theory is presented before evidence, and the two are not always dissociated clearly. The illustrations are excellent, the photographs being reproduced by gelatine process, and the original drawings of fossils successfully treated in the same way.

J. E. W.

Notes on the Tellurides from Colorado. By CHARLES PALACHE. *(Am. J. Sci., 160,* 419-427.)

The article gives the results of a careful and admirable crystallographic study of the mineral sylvanite together with a chemical investigation of the same. The analyses show the composition to be represented by the formula $Au\ Ag\ Te_4$, thus confirming the conclusions previously reached by Pearce from analyses made by him on massive material from Cripple Creek. The goldschmidtite of Hobbs is shown by Dr. Palache to be identical in crystallization with sylvanite. Owing to this identity it is thought that the analyses made by Hobbs may have been rendered inaccurate by the extremely small quantity with which he worked, and in a note incorporated in the article, Prof. Hobbs withdraws the name goldschmidtite as representing a distinct species. The article is concluded by a note on the crystal habit of hessite from Boulder, Colorado. C. H. W.

Mohawkite, Stibio-Domeykite, Domeykite, Algonodite and some artificial copper arsenides. By GEORGE A. KOENIG. (*Am. J. Sci., 160,* 439-448.).

The copper arsenides occurring in the Keweenaw copper formation of Michigan are found only in veins intersecting the bedded deposits of native copper, and have so far, been observed only near the foot of the formation toward the south-east. The new mineral mohawkite occurs in a vein at the Mohawk mine associated with other copper arsenides in a gangue of quartz and calcite. The mineral is massive, structure granular to compact, color a gray tinged with yellow taking readily a brassy to purplish tarnish. It is brittle, hardness about 3.5 with a specific gravity of 8.07. A chemical analysis gives its composition as follows: Cu=61.67, Ni=7.03, Co=2.20, Fe= trace, As=28.85, which gives the mineral the formula $(Cu, Ni, Co)_3As$. The author shows also that nickel and cobalt are present in small quantities in the mineral domeykite Cu_3As, and, that the specific gravity of the latter should be 7.94 instead of 6.7 to 7.5 as given by the mineralogies. By volatilizing arsenic over red hot copper in a combustion tube sealed at one end two arsenides were obtained, one having the composition Cu_3As and resembling chalcocite, the other consisting of groups of minute crystals and identical with domeykite in composition. By the name stibiodomeykite the author designates a mineral from the Mohawk mine closely resembling domeykite but containing a small percentage of antimony; and by the name mohawk-whitneyite a very intimate mixture of the two minerals mohawkite and whitneyite. The results of several analyses of these last mixtures accompany the article. The correctness of the formula $(Cu\ Ni\ Co)_4As$, which was assigned to mohawkite by Dr. Ledoux and reported in the April number of the *Mining Journal* for 1900, is strongly denied by Dr. Koenig. He concludes his paper with a new analysis of algodonite, confirming the formula Cu_6As. Its specific gravity was found to be 8.383 instead of 7.62 as previously given. C. H. W.

The analyses of Italian volcanic rocks. By H. S. WASHINGTON. (*Am. J. Sci., 159,* 44-45)

Analyses are given of the following types of rocks: ciminyte, from Monte Cimino, Viterbo; mica trachyte (selagyte), from Monte Catini, Tuscany; andesyte, from Radicofani, Tuscany; leucityte, from Capodi Bove, Alban Hills. A discussion is made of the analyses, the mineralogical composition of the rocks and their classifications in accordance therewith. C. H. W.

Occurrence of native lead with copper and other minerals at Franklin Furnace, N. J. By W. M. FOOTE. (*Am. J. Sci. 156,* 187-188.)

Small irregular masses of lead 1 to 2 mm. in diameter, associated intimately with native copper and a variety of minerals—among them axinite, garnet, willemite and phlogopite—have been found on a few specimens taken from the 800-foot level of the Parker shaft on North mine hill. The rarity of native lead and its associations at Franklin make the discovery interesting. C. H. W.

Occurrence of sperrylite in North Carolina. By W. E. HIDDEN. (*Am. J. Sci., 156,* 380-381.)

The mineral sperrylite a di-arsenide of platinum—is described from Macon county, N. C., where it was discovered in the sands of Cowee creek, associated with a little gold and the minerals monazite, zircon and menaccanite. The sperrylite consisted of a few very minute, nugget-like particles and crystals, the latter showing the combination of the cube and octahedron. C. H. W.

Thomsonite, mesolite and chabazite from Golden, Colorado. By HORACE B. PATTON. *Bull. Geol. Soc. Am., vol. 17*, pp. 461-474. pls. 43-49.

The paper gives a detailed description, supplemented by excellent plates, of the occurrence and habits of the above named zeolites, found in a scoraiceous band of the basalt flow which caps what is known as Table mountain near Golden. C. H. W.

Beiträge zur Burtheiling der Brachiopoden. Von DR. F. HUENE. (Centralblatt fur Mineralogie &c., 1901.)

This pamphlet is a critical review of the studies of F. Blochmann on the Brachiopoda, and a comparison of his results with those of Beecher and Schuchert.

The part of these studies so far published refer to Discina, Discinisca Lingula and Crania and they bring to light some important characters in the morphology of the Inarticulata not heretofore recognized. The reviewer lays considerable stress upon an important distinction between the Articulata and Inarticulata in the properties of the pedicle. In the latter division the motions of the pedicle are automatic and it has no attached muscles, in the former the pericle itself is immobile, and its motions are governed by muscles attached within the shell.

Another important point brought out by Blochmann is that the opening of the valves in the Inarticulata is effected by the contraction of the "Cutanei" or muscles of the body-wall which by squeezing the viscera and cavity in which they are contained, force the valves apart; he claims that the internal muscles have very little power for this purpose.

Another important observation of Blochmann is that the pedicle is a continuation *backward of the ventral valve,* and is in organic connection with it; the supporting substance of the pedicle within its cuticle being an *extension of the body-wall of the brachiopod.*

Blochmann finds that the circulation of the mantle in the sinuses &c. is of a respiratory nature, and shows how the observations of Morse of two inlet and one outlet current in Lingula are in accordance with his observations. There is no venous circulation in these passages, the blood being contained in tubes of microscopic size.

The notation for the muscles in Blochmann's work differs from that lately current in English literature. The only laterals recognized are the "j" laterals; the other laterals with the transmedians are "oblique." As the pedicle is automobile, no muscles are required for it within the shell, and the connected threads are "nervi."

The observations in this review are made more instructive by a number of figures in the text, cited from Blochmann's work, and showing the various points of structure discussed in this review. Dr. von Huene directs deserved attention to the important work of Beecher and Schuchert on the classification and morphology of the

Brachiopoda, though he lays a strong emphasis on the distinction between the "Ecardines" and "Testicardines" (=Inarticulata and Articulata.) G. F. M.

Kleine paleontologische Mittheilungen. von Dr. F. Huene in Tübingen. mit 2 Taf. (Neu Jarb. für Mineralogie &c, 1901, Bd. I, s. 1-8.)

In this article Baron v. Huene describes a new species of Medusa (*Medusina geryonides*) from the Murchisonia slate of Wiesenteig in Wurtemburg of which the preserved impression exceeds an inch in diameter and is quite distinct and characteristic.

He also gives figures and a descripion of a new Cycad *(Zamites infraooliticus)* from the Blagdini zone near Langenbruck in Switzerland. The oroginal of this species is in the museum of Lausanne.

G. F. M.

Action of Ammonium Chloride upon Analcite and Leucite. By F. W. Clark and Steiger. (*Am. J. Sci., 159,* 117-124.)

The article records the results of an investigation on the action of ammonium chloride upon the minerals analcite and leucite when the latter are heated separately with this reagent in sealed tubes at 350°C; also the meaning which the results obtained have in regard to the chemical constitution of the two minerals. Both minerals suffer a substitution of their alkali by ammonium, yielding the same compound whose composition is that of an ammonium leucite, $NH_4AlSi_2O_6$. This fact is believed to indicate an original similarity in the two minerals which is also borne out by crystallographic and other resemblances. A further study of the chemical properties of the ammonium derivative leads the authors to think that analcite and leucite are not true metasilicates but either salts of a polymeric metasilicic acid or a mixture of ortho and tri-silicates. C. H. W.

Chemical Study of the Glaucophane Schists. By H. S. Washington. (*Am. J. Sci., 161,* 31-59.)

A consideration of the chemical and mineralogical composition of the above class of metamorphic rock as shown by a series of admirable chemical analyses of specimens from some seven localities, leads to conclusions concerning their classification and origin which are briefly and concisely given by Dr. Washington in his summary as follows: "The Glaucophane schists belong to two main groups, sharply separated from each other. The larger one is basic, composed chiefly of glaucophane and epidote, often with abundant garnet, zoisite, diallage, and sometimes smaller amounts of mica, feldspar and quartz, and rutile and titanite as frequent accessories. Chemically these closely resemble the composition of the rocks of the gabbro family, and are apparently divisible into two sub-groups, one high in CaO, the other low in it. These are in most cases almost undoubtedly derived from such igneous rocks or their tuffs. but also possibly in rarer cases from sediments or slates of similar composition. These basic glaucophane schists scarcely differ in composition from the amphibolites and eclogites, and the difference in their formation is probably to be ascribed to differences in the conditions of metamorphism. A smaller but widely spread, group is acid in composition, and these are composed largely of quartz and glaucophane, with mica and sometimes albite. These are derived from cherts, quartzites or quartzose shales and sandstones. The existence is indicated of a third, still smaller group of intermediate mineralogical composition, and chemically like the diorites. The glaucophane schists are apparently the result of both regional and contact metamorphism, and in many regions they occur together. This last seems to be the rule in glaucophane schist areas of any size, and where only the one kind is found the area is apt to be small." C. H. W.

The Mode of Occurrence of Topaz Near Ouro Preto, Brazil. By ORVILLE A. DERBY. (*Am. Jour. Sci., 161.* 25-34.)

The article gives the results of a study of the associated earths and rocks where the topaz is found. The mineral itself is found in a dark-colored earth, thought, from its mineralogical character and its geological relations, to represent the remains of an igneous dike in which the topaz was an original mineral. What the exact nature of the igneous dike was cannot be told on account of its state of extreme alteration. C. H. W.

Carnotite and Associated Vanadiferous Minerals in Western Colorado. By W. F. HILLEBRAND and F. LESLIE RANSOME. (*Am. J. Sci., 160.* 120-144.)

The paper embodies the results of investigations concerning the occurrence and nature of the uranium and vanadium ores of western Colorado. A somewhat detailed description of the various ore deposits is given by Dr. Ransome from a study of the region made by him and Dr. A. C. Spencer. He concludes that the ores are recent impregnations in the sandstones. The chemical researches made and recorded by Dr. Hillebrand furnish, not only valuable data concerning the composition of the ores and their constituent minerals, but afford the chemist excellent descriptions of the analytical methods involved in the analysis of the uranium and vanadium ores. The summary made by the authors is as follows: "The body called carnotite is probably a mixture of minerals of which analysis fails to reveal the exact nature. Instead of being the pure uranyl-potassium-vanadate, it is to a large extent made up of calcium and barium compounds. Intimately mixed with it and entirely obscured by it is an amorphous substance—a silicate or mixture of silicates—containing vanadium in the trivalent state, probably replacing aluminum. The deposits of carnotite, though distributed over a wide area of country, are, for the most part, if not altogether, very superficial in character and of recent origin. The green coloring and cementing material of certain sandstones near Placerville, Colorado, is a crypto-crystalline alumino-vanadio-potassium silicate resembling roscoelite, but with the percentage proportions of Al_2O_3 and V_2O_3 reversed. It constitutes over 25 per cent. of the sandstone at times, and contains nearly 13 per cent. of V_2O_3, the latter amounting in the maximum case observed to 3.5 per cent. of the sandstone. As yet these highly vanadiferous sandstones have been found only at Placerville where it is intended to work them for vanadium. Carnotite is associated with them in only trifling amount. Other sandstones colored owe their bright green color to chromium. In yet another case where the color was still green, this was not due to either chromium or vanadium. C. H. W.

A Contribution to the Natural History of Marl. By CHARLES A. DAVIS. (*Jour. Geol.*, v. 8, pp. 485-497.)

This valuable contribution to the chemistry of marl is based upon observations made in certain small lakes in Michigan, but the principles which it embodies undoubtedly admit of general application. The marl is nearly pure carbonate of lime, the source of which is to be sought in the solution by meteoric waters of limestone or other calcareous strata, the drift of limestone districts and, more remotely, the carbonation of lime-bearing silicates. The real problem is the deposition of this dissolved carbonate of lime in the form of white chalky marl which consists only to a small extent of shells or fragments of shells. After pointing out the inadequacy of animal life, evaporation and escape of carbon dioxide on relief of pressure, as causes of the precipitation of the carbonate of lime, the author discusses at length the only alternative hypothesis, namely, that the calcium salts are precipitated through the agency of plant life. In the marly lakes aquatic plants of all kinds become incrusted with calcium carbonate, which is not a true secretion of the plants, for it is purely external, and the same species in other districts are not incrusted. The deposit is formed incidentally by chemical precipitation upon the surface of the plants, probably only upon the green parts, and in performance of normal and usual processes of the plant organism. All green plants inhale carbon dioxide and exhale oxygen and these are two possible causes of the calcareous incrustation. If the calcium carbonate is in excess in the water and is held in solution by carbon dioxide, then the absorption of the latter by the plants causes precipitation of the carbonate upon the parts (stems and leaves) abstracting the gas. But if the proportion of calcium carbonate in solution is so small that it would not be deposited even if there were no carbon dioxide present, the precipitation is explained by the action of the oxygen set free by the living plants in converting calcium bicarbonate to monocarbonate:

$$CaH_2(CO_3)_2+O=H_2O+CaCO_3+CO_2+O.$$

Plants vary greatly in their power of precipitating the calcium carbonate, and the algae, and especially the Characes or stoneworts, are most efficient. Analyses are given showing that plants may precipitate mineral matter equal to several or many times the weight of their own dried tissues, that this mineral matter consists of CaO_3, 93.76; $MgCO_3$, 2.93; SiO_2, 2.40; and iron and aluminum oxides 0.89 per cent. It is shown that the structure and distribution of the marl are entirely in harmony with the view that a species of Chara is an important agent in its formation; but it is recognized that a species of Zonotrichia has always played an important part, explaining, especially, the more solid and nodular forms of the marl. W. O. C.

The Composition of Kulaite. By HENRY S. WASHINGTON. (*Jour. Geol., 8,* 610-620.)

Kulayte is the name given by the author several years ago to a subgroup of the basalts in which hornblende occurs as an essential constituent and surpassing augite in quantity and importance. The original analysis by Röhrig showed, for basalts, abnormally high soda, as well as very high alumina and low magnesia. There seemed to be no mineral present which would account for the high alkalis, and to determine this and other points two new analyses were undertaken, one of normal kulayte, and the other of a leucite kulayte. The first showed in comparison with Röhrig's analysis, about two per cent. more Fe_2O_3 and as much less K_2O; and the second differed rather widely except for the MgO, CaO and Al_2O_3. It is surprising to find that all these differences are regarded as probably due to the different analytical methods used. The normal and leucite kulaytes are found to agree closely except in the minor constituents TiO_2 and P_2O_5; and the author next considers the place in the classification indicated by this composition. The alkalis and alumnia are shown to be high for a true basalt; and for these reasons and also becuse of the higher SiO_2 and the lower iron oxides, MgO and CaO, they cannot be referred to the subgroup of hornblende basalts. They are, in fact, properly leucocratic, while the hornblende basalts are melanocratic; and the closest analogues of the Kala rocks are to be found among the nepheline-tephrytes and the nepheline-basanytes, notwithstanding that many of these are markedly lower in SiO_2, Al_2O_3, and Na_2O. A resemblance to the monchiquytes is also noted, the main difference being the higher H_2O content of the latter. Except in the glassy varieties, the essential hornblende has been partially or entirely altered to hypersthene, diopside and magnetite, The component minerals are calculated from the analysis, and nepheline, the presence of which was indicated by the gelatinization and fuchsine tests, is fully confirmed. Certain anomalies of the mineral composition, such as a large proportion of orthoclase in the more basic type, and of leucite in the type running highest in SiO_2 and lowest in K_2O, are explained by reference to difference in pressure and rate of cooling; and the author favors basing the classification of this and other rocks directly upon the chemical composition. W. O. C.

A Topographic Study of the Islands of Southern California. By W. S. TANGIER SMITH. (Bull. of the Department of Geology, University of California, vol. 11, pp 179-230, 1900.)

The islands described in this bulletin were studied principally from maps, and the conclusions reached are intended to be rather preliminary and suggestive than final in character. The topographic feature of the islands are outlined and a general discussion given of the characteristics of the various kinds of shore terraces and of the conditions leading to their formation.

There follows an interesting account of the oscillations of the Pacific coast in Miocene and Pliocene time. The information in this account is not new. The principal point which the present paper aims to establish is that the most recent general movements have been the same for the islands as for the coastline of southern California. I. H. O.

A Remarkable Marl Lake. By CHARLES A. DAVIS. *(Jour. Geol., 8,* 498-503.)

This paper supplements the preceding, describing the truly impressive deposit of marl in Littlefield lake, Isabella county, Michigan, and showing that it is unquestionably due to the precipitating agency of Chara and Zonotrichia, chiefly through the exhalation of oxygen.

W. O. C.

CORRESPONDENCE.

NOTES ON THE KANSAS-OKLAHOMA-TEXAS GYPSUM HILLS.—From the time of the earliest explorations of the great plains the gypsum hills have been objects of particular interest. Long and Marcy, among early explorers, and Hay, Cummins, Cragin, Prosser and Grimsley, among later geologists, have written extensively concerning these very interesting formatiohs. Conspicuous on account of topography, color and position, these hills have ever excited an interest both popular and scientific.

Geologically the gypsum hills are a part of the "red-beds" and are located near the center of that series. The red-beds consist of more than 2,000 feet of prevailingly red clays, shales and sandstones. The series extends from near the great bend of the Arkansas river in southern Kansas across Oklahoma and far into Texas before it finally disappears beneath the later Mesozoic and Cenozoic deposits. The age of the rock has long been a mooted question. In Texas it has been correlated with the Permian. In Kansas and Oklahoma it was for a number of years classified as Triassic, but the later geologists have inclined to the opinoin that the red-beds of this region are of the same age as those of Texas, *i. e.,* Permian. No fossils have been found in the Kansas beds and until the past year very few in Oklahoma. During the summer of 1900, however, the Oklahoma Geological Survey collected fossils from several localities in the red-beds. These fossils—vertebrates from the lower part of the series, and invertebrates from the upper part—indicate that in Oklahoma at least the red-beds belong to both the Permian and Triassic.

Throughout the entire thickness of the red-beds the rock is strongly impregnated with mineral salts. In the lower part common salt predominates. In Oklahoma there are no fewer than four large salt planes, and numerous smaller ones. In general the salt planes are confined to a definite horizon. Even among the saliferous horizons gypsum is of frequent occurrence. Seams of selenite and satin spar are often abundant.

Some 200 feet above the salt beds the gypsum reaches its culmination. At this horizon there are thick ledges of massive white gypsum which lie level and extend for long distances across the country. Ordinarily there are two of these ledges, each from 10 to 30 feet thick separated by 10 to 20 feet of red clay shale. Professor Cragin has given this massive gypsum the name "Cave Creek gypsum," from a creek in Comanche county, Kansas. The lower (and usually thicker) gypsum ledge he calls the Medicine Lodge gypsum, and the upper ledge the Shimer gypsum. The intervening clays are designated as the Jenkins clays.* It frequently happens, however, that this clay entirely disappears, in which case the single gypsum ledge is as much as 50 feet thick. On the other hand in certain sections there are three ledges of gypsum, a thinner ledge coming in below the Medicine Lodge.

The gypsum hills are hills of erosion. The soft clays below the massive ledges are readily acted upon by water. The ledges themselves are relatively much harder and consequently resist erosion. The slope of the country is to the east, while the ledges lie comparatively level. This causes the greater erosion to the east, and as the underlying clays are removed the gypsum ledges remain as a cap forming the escarpment of the hills, which rise like a wall from the level plains to the east. The slopes below this escarpment are often as much as 200 or 300 feet high, and consist of blood red clays, sometimes grass-covered but more often barren of vegetation. These slopes are often covered with selenite crystals, which on a clear day reflect myriads of light-points and have given to one part of the hills the characteristic name "glass mountains."

Throughout the region of the gypsum hills there are numerous pronounced erosion forms. Deep and narrow canyons, flat-topped mesas, pinnacles and turrets, mansard mounds and buttes, and natural bridges and caves may be found in most localities. These forms are due not only to the solubility of the gypsum ledges but also to the fact that the underlying clays are so easily eroded. The gypsum caves are of particular interest. They are of all sizes from mere cracks in the rock to immense caverns a mile or more in length with sometimes dozens of chambers leading off in all directions. In southern Kansas and northern Oklahoma many of these caves are known locally as "bat caves" from the fact that they are the home of multitudes of bats. These animals remain inside during the day and in the evening pour out of the mouth of the cave in a continuous stream, sometimes for an hour at a time.

The gypsum hills extend in a general northeast and southwest direction for a distance of nearly 500 miles from southern Kansas to west-central Texas. The northern limit so far as I have been able to observe is in northwestern Barber county, Kansas, on the north bank of the Medicine river, near Sun City. From this point the hills trend southeast and approach within six miles of Medicine Lodge, where a bold outlier east of the main line of hills overlooks the valley of the Medicine river. The line of hills crosses the Salt Fork at the state line and approaches the Cimarron in the northeastern part of Woodward county, Oklahoma. Throughout nearly its entire course in this county, a distance of 40 miles the Cimarron flows in a narrow valley enclosed between the hills. In places the valley is little more than a canyon with precipitous walls 100 feet or more in hight. The gypsum hills trend southeast along the south side of the Cimarron as far as the Glass mountains in southern Woods county, and then gradually retreat from this river and approach the North Canadian near El Reno. From this point at which the hills find their most eastern limit, they trend southwest across the Kiowa and Commanche reservation to the Red river. In Texas extensive gypsum deposits occur at Quanah, Hardman county, and in Stonewall, Kent and Knox counties as far as Sweetwater on the Texas Pacific railroad.

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* *Colorado College Studies, vol. vi,* March, 1896, pp. 27-39.

Throughout this area, from Kansas to Texas, the region of gypsum deposits is from 10 to 50 miles wide and is in all places much cut up with canyons and streams. Certain parts of the range have received particular names, as for eaxmple: Glass mountains, Chautauqua mountains, Stony hills, Cedar hills and Gray Eagle and Wild Cat buttes. For the entire range in Oklahoma the name "Marcy" range has been proposed, but it need scarcely be feared that any other name will ever take the place of the good old cowboy phrase, "Gyp." hills.

In regard to the economic importance of the gypsum it is but necessary to add that mills for manufacturing the product are in operation in all three states in which the hills are found. Of these perhaps the most important are located at Springvale and Medicine Lodge, Kansas, Okarche, Oklahoma, and Quanah, Texas. As the supply of material is inexhaustible it is but a matter of time when the gypsum from the Gypsum hills will become one of the important sources of income from the region. CHARLES NEWTON GOULD.

University of Oklahoma, Feb. 1, 1901.

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OF AMERICAN GEOLOGICAL LITERATURE

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PERSONAL AND SCIENTIFIC NEWS.

Lake Superior Iron Trade During the Year 1900. Considering the fact that the close of the century marks also the end of the first half-century of activity in the iron mining region of lake Superior, the development has been one of the most astonishing of this wonderful age. It is a short half-century, too, for no mining of importance could be done until there was water connection between lake Superior and the east, and this did not come until 1855. In that momentous year the first ship canal at the foot of lake Superior was cut and the Jackson mine began small shipments of ore. For years the industry was small, it was the day of 8-ton railway cars or, still more primitive, of mule railroads, of 500-ton ships, hand drills, black powder, open pit mining and the like. It was the day of beginnings and of small things, in a word. For some years the product of the lake Superior mines was handled over a mule tram road to Marquette. Up to ten years later or nearly to 1870 a 700-ton ship was an enormous craft and the loading of this great ship required two days and its unloading more than that. Many men of today remember sales of ore at Pittsburg at $18, or about the price of steel billets now. Instead of the tram road there are eight great railways engaged in the ore business hauling cars loaded with 50 tons each behind locomotives of 240,000 pounds weight. Instead of the 700-ton ships, those of the beginning of the new century carry 7,000 or 8,000 tons, and instead of consuming four or five days in loading and unloading they are loaded in two hours and emptied in ten. Instead of ten to twelve trips a year they are making twenty to twenty-five. In connection with this, instead of old time prices ore is now bringing on lake Erie docks little more than the actual mining cost of early years, and in the past three years has actually sold when delivered at Cleveland at less than the mining expenses of as late as 1887. Not longer ago than 1871 a drift was driven at the Cleveland mine at a cost of $100 per foot. Now it could not cost $15. Nitro-glycerine and power drills have been the humanizing and civilizing agencies in great measure, and civilizing these have surely been, for where would be our supremacy today but for the reduction in costs they have brought about?—*D. E. Woodbridge in Mines and Minerals for February.*

MR. FRANK LEVERETT has completed and submitted for publication by the U. S. Geol. Sur., his second monograph: "The Glacial Formations and drainage features of the Erie and Ohio basins."

THE FIELD COLUMBIAN MUSEUM has arranged a course of nine free lectures to be given in the Museum lecture-hall in March and April. These are to be illustrated by stereopticon views: The geological lectures are by Dr. E. R. Buckley and Prof. Wm. H. Hobbs.

SCIENCE CLUB OF NORTHWESTERN UNIVERSITY. At the meeting of February 1st Prof. U. S. Grant spoke on "Some methods of geological field work," and at the meeting of March 1st Prof. A. R. Crook spoke on "Minerals of the Chicago area."

GEOLOGICAL SOCIETY OF WASHINGTON. The following was the program of the meeting held February 27th: "Memorial of Thomas Benton Brooks," Bailey Willis; "Morphogeny of southern Alaska," G. K. Gilbert; "Mountain structure in the trans-Pecos province," Robert T. Hill.

THE GEOLOGICAL SURVEY OF GEORGIA has just issued Bulletin No. 10—A, entitled "A preliminary report on a part of the iron ores of Georgia, Polk, Barton and Floyd counties." The report is made by Mr. S. W. McCallie, assistant geologist.

MR. F. A. LUCAS, geologist of Washington, D. C., who has been drilling for oil in Texas for about two years, was rewarded by the discovery, on Jan. 10, of a great oil basin. The flow of oil at Beaumont is said to be greater than from any single well ever sunk in the United States. It is estimated by experts that every twenty-four hours it flowed 20,000 barrels of oil, and that 150,000 barrels escaped from it before the flow could be regulated. It is not an illuminating oil, but is similar to that now so abundant at Los Angeles, California.

OIL HAS BEEN DISCOVERED IN THE PHILIPPINES, and is extracted in Panay, Luzon, Mindanao and other islands. In most cases it is in a stratum of rock about 350 feet below the surface The working is done by the natives, but largely with machinery from America.

W. H. WEED, WHO HAS RECENTLY SPENT SOME TIME in Mexico, has returned to this country, and is now engaged in the final investigations at Butte, Montana, preliminary to the publication by the U. S. Geological Survey of an exhaustive report upon the economic geology of the Butte district. Mr. Weed expects to complete his studies at Butte in about a year, and will then probably commence the study of the copper region of New Mexico.

C. W. CLARK, son of U. S. Senator W. A. Clark, of Montana, has endowed the Chair of Mining Engineering in the Montana State School of Mines, located at Butte, Montana. The chair thus established has not yet been filled.

THE ANACONDA COPPER MINING COMPANY has presented to the Montana State School of Mines a rock cutting and a rock grinding machine of the best make, and equipped with all accessories. It has also presented to the Museum a specimen of chalcocite weighing 3,500 pounds—doubtless the largest of its kind anywhere on exhibition. It was taken from the Never Sweat mine, one of the Anaconda group at Butte.

THE AMERICAN ASSOCIATION FOR THE ADVANCEMENT OF SCIENCE will hold its next annual meeting at Denver, Colorado, August 24 to 31.

THE AMERICAN INSTITUTE OF MINING ENGINEERS. The eightieth meeting (being the thirty-first annual meeting) was held in Richmond, Va., beginning Tuesday evening, February 19.

MR. J. EDWARD SPURR, at one time connected with the Minnesota Geological Survey, and more recently with that of the National Government, has been appointed geologist to the Sultan of Turkey, at a liberal salary and all traveling expenses for himself and family, and will shortly depart for his new field of labor, with leave of absence for one year from the U. S. Geological Survey. It is understood that he is also to have a share in any discoveries that he may make, and that he is to be provided with suitable assistants and a body guard of soldiery.

MAJ. A. W. VOGDES, who has been at San Juan since the Spanish war, has returned to New York, and has his address at Fort Hamilton.

A BRONZE BAS-RELIEF of the late Dr. J. S. Newberry has been presented to Columbia University by his children.

TRIBUTE TO VICTORIA. At a postponed meeting of the Ottawa Field Naturalists' Club held on the 29th day of January, 1901, one week after the death of Her Majesty Queen Victoria, the following resolution was unanimously passed: "In common with all the sorrowing subjects of His Imperial Majesty King Edward VII. the members of the Ottawa Field-Naturalists' Club desire to express their deep sense of sorrow and loss at the demise of their beloved Sovereign Lady, Queen Victoria, during whose glorious reign of sixty-four years, scientific work and research, such as our Club aims to accomplish, have received unprecedented impetus." At the last meeting of the same Club, held on Tuesday, Feb. 12th, Dr. R. W. Ells read his paper entitled, "Ancient Channels of the Ottawa River."

THE TECHNICAL STAFF of the Canadian Geological Survey is being rapidly depleted. Amongst those who have resigned are: Dr. A. C. Lawson, Dr. F. D. Adams, and Messrs. Eugene Coste, E. B. Kenrick, W. P. Ferrier, A. J. Cole, J. B. Tyrrell and A. P. Low.

DR. OTTO KUNTZE IS UNDERTAKING to supply a series of typical Monticuliporoidea in thin sections with specimens to those who may desire to purchase them. Whether these fossils are Bryozoa or are corals may be left for specialists to decide. The materials offered by Dr. Kuntze will in either case be of great value as an aid to the study of monticuliporoids.

MR. A. P. LOW, of the Geological Survey of Canada, it is understood has accepted a lucrative position in connection with one of the Nova Scotia trusts. Mr. Low has been regularly employed on the staff of the Geological Survey of Canada since 1882 and was last year appointed one of the Commissioners for Canada at the Paris Exposition.

MR. R. D. LACOE, a well-known geologist and collector of Carboniferous fossil plants, of Pittston, Pa., died Feb. 5, 1901.

BILLINGS MEMORIAL PORTRAIT. A fine oil portrait by Moss, R. C. A., of the late ELKANAH BILLINGS, was recently presented to the director of the Geological Survey of Canada and can now be seen adorning the wall of the stairway in the front hall leading to the museum of the survey, on Sussex street, Ottawa. The portrait was presented by a committee of the Ottawa Field-Naturalists' Club, who acted on behalf of the subscribers to the Billings' memorial portrait fund, and the following inscription accompanies the portrait:

ELKANAH BILLINGS, Esq., F. G. S.
Palæontologist from 1856 to 1876.

Presented to the Geological Survey of Canada by a Committee of the Ottawa Field-Naturalists' Club, Dec. 11th, 1900, on behalf of his friends and admirers.

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THE
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THE GRANITIC ROCKS OF GEORGIA AND THEIR RELATIONSHIPS.*

By THOMAS LEONARD WATSON, Geol. Surv. of Georgia, Atlanta, Ga.

PLATES XVII-XXIV.

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INTRODUCTION.

In the present paper it is proposed to give a summary of the results obtained from several years' careful field and laboratory study of the granitic rocks, comprised within the limits of the Piedmont Plateau region of Georgia.

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* Published by permission of the *State Geologist of Georgia*. The writer wishes to acknowledge his indebtedness to PROF. JAMES F. KEMP, of Columbia University, for kindly reading and criticizing this paper in manuscript.

The Piedmont plain in Georgia represents the southern prolongation of the similar physiographic province in Virginia and the Carolinas. It is a well dissected low-land plain of holocrystalline rocks, crossing the state in a south of west course, and skirting the southeastern border of the Appalachians with a gentle seaward slope, and passing on the southeast beneath the Coastal plain sediments. The plateau has a general average elevation of 350 to 450 feet above sea level, along the line of contact with the Coastal plain formations, and an average elevation of 1,000 feet along its northwestern border. A few unreduced areas—residuals—of moderate elevation, rise above the general level of the plain, which, as a rule, represent parts of harder rock-masses remote from the major streams.

The prevailing rocks forming the Plateau-crystalline-complex are mica-schists, gneisses and massive granites. The schists more particularly, are cut by numerous well-defined dikes of basic eruptives, diabases and diorytes,* which vary from several inches to as many hundred feet in width; and, in one or two cases, have been traced for some miles in length.

The mica-schists form a large part of the rock-complex. They vary somewhat in color; are thinly foliated rocks, and show considerable variation according to locality in the proportion of mica and quartz and often feldspar. More or less feldspar is invariably present. The increase in this constituent may possibly mark in places the transition from schists into certain gneisses of granitic composition. This can in nowise apply, however, to the gneisses thus far studied in this area, since, in many instances, sharp contacts are plainly marked between the two rocks. The basic dike rocks vary from fine to coarse granular in texture; they are occasionally porphyritic and frequently banded in structure, and gray to black in color. The usual normal rock-types are present, which, as a rule, present no unusual features in mineral composition. The dikes are limited for the most part, to the enclosing schists and are rarely actually seen cutting the granitoid rocks. The granitic rocks are traceable across the entire width of the state, and are accordingly of wide distribution throughout the Piedmont area;

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* Other basic rocks usually laminated or thinly schistose in structure and somewhat porphyritic in places, simulating dikes and grouped for the *most* part at present, as amphibolytes have not been sufficiently studied to warrant definite statements.

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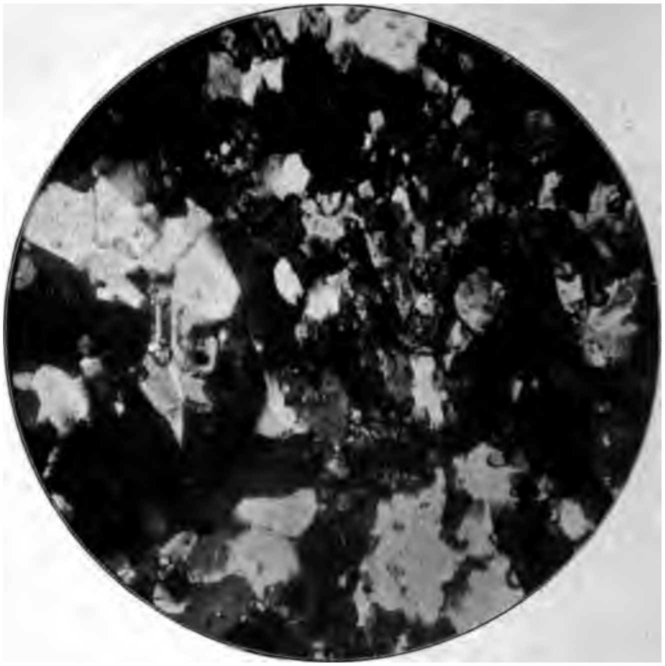

PLATE XVII. FIGURE 1. PHOTOMICROGRAPH OF HORNBLENDE SCHIST (AMPHIBOLITE) CONTAINING MUCH EPIDOTE. FOUR MILES SOUTHEAST OF LAWRENCEVILLE, GEORGIA. CROSSED NICOLS x74.

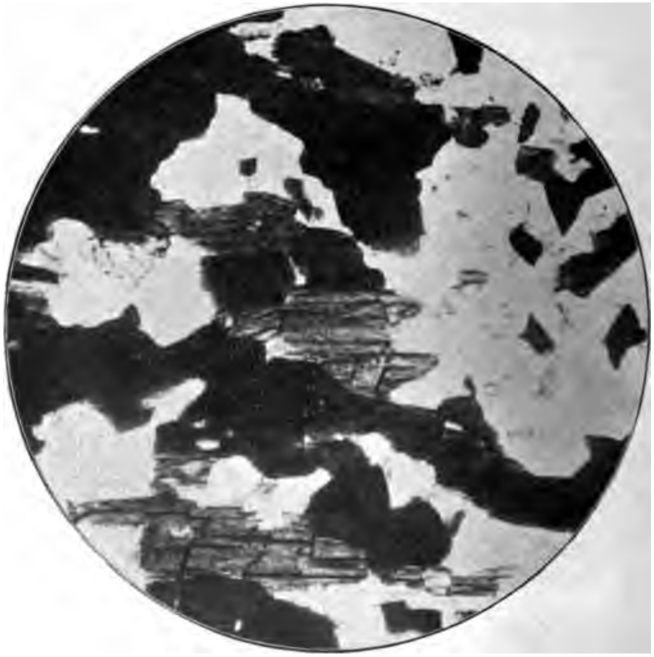

FIGURE 2. PHOTOMICROGRAPH OF HORNBLENDE GNEISS (AMPHIBOLITE). MERIWETHER COUNTY, GEORGIA. x74.

and are associated with similar rocks continuously into South Carolina.

In the western section of the plain, near the Alabama line, somewhat extensive belts of very dark-colored, thinly banded hornblende gneisses or amphibolytes are met. [Plate XVII, figures 1 and 2.] They are strongly contrasted with the granitic gneisses with which they are intimately associated. In thin sections, hornblende of a greenish-brown and blue color makes up half the rock or more. Plagioclase is the prevailing feldspar, but orthoclase and quartz in variable amounts always accompany it. Epidote is a frequent characteristic accessory.

On general textural and structural grounds, the granitoid rocks are grouped and separately treated under three general headings: (a) The even-grained, normal, massive granites, (b) porphyritic granites, and (c) granite-gneisses.* The relationships of the three phasal aspects of the granite rocks are established in the succeeding paragraphs.

(A) THE EVEN-GRAINED, NORMAL, MASSIVE GRANITES.

Granites of superior quality and variety, well-suited for general building and monumental work, have long been known in Georgia. Their extent, distribution, physical, mineral and chemical characters, however, are almost entirely unknown, since no systematic geological work has been undertaken. Until quite recently, the famous Stone mountain light-gray biotite-bearing muscovite granite was the only type of Georgia granite known outside the state. Within the past few years, however, several areas yielding a high grade monumental granite have come somewhat prominently into favor in some sections of the United States.

PETROGRAPHY.

With two exceptions, all the granites are biotite granites. Muscovite is prevailingly present in variable amounts, and very prominent as an accessory in some places; while hornblende fails entirely. They are described under the following types: The Oglesby-Lexington blue-gray; the Elberton-Echol's Mill light-gray; the Campbell-Coweta-Meriwether counties' medium blue-gray; the Stone mountain light-gray.

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[*] The term granite-gneiss is used in this paper to denote gneisses derived from massive granites by metamorphism, and therefore igneous in origin, as contrasted with those gneisses of known sedimentary origin.

Numerous smaller areas are widely distributed over the Piedmont region, but, in the cases studied, they naturally fall into one or the other of the types mentioned above, separate descriptions of which are unnecessary and beyond the scope of the present paper.

THE OGLESBY-LEXINGTON BLUE-GRAY GRANITE. The Oglesby-Lexington belt of dark-blue granite is continuous for thirty miles in a northeast-southwest course, with an average of four to six miles in width. Practically no variation in texture is noted within these limits, but appreciable color variation is apparent in places, according to the quantitative variation in the biotite constituent.

This variety consists of anhedra of an average size, 0.5-1.5 millimeters. [Plate XVIII, figure 1.] The texture is hypidiomorphic granular. Simple Carlsbad twins among some of the feldspars are readily recognizable in many of the hand specimens. The principal minerals are quartz, orthoclase, microcline, plagioclase near oligoclase, biotite, some muscovite, a little included apatite and zircon, and occasional grains of magnetite and pyrite. Secondary chlorite, epidote, muscovite and kaolin are present to some extent. In addition, as an interstitial constituent, quartz is frequently present in drop-like inclusions in the larger feldspar individuals; and, at times, is intergrown with a part of the feldspar in the form of ovals or rounded discs of micropegmatitic intergrowths. The period of growth of the quartz and feldspar was in part simultaneous. Orthoclase is the predominating feldspar present, and frequently exhibits microperthitic intergrowths with a second feldspar, probably albite. Microcline varies in quantity, but at times may equal the orthoclase. The habit of simple Carlsbad twins is common to the two potash feldspar varieties. The plagioclase is always inferior in amount to the potash feldspars, and, as a rule, gives low extinction angles in basal sections. The percentage of lime in the analyses given below with the microscopic evidence indicates oligoclase as the triclinic feldspar present. The biotite is regularly distributed through the rock in irregular drawn-out single shreds and foils, deep brown in color and strongly pleochroic. It is intimately associated with foils of muscovite and is partially altered to chlorite. The remaining accessories present no note-worthy features.

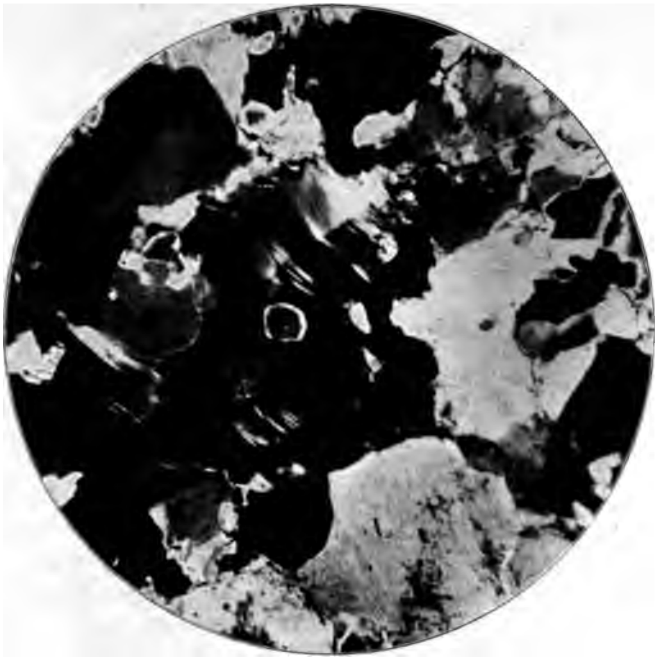

Plate XVIII. Figure 1. Photomicrograph of the Oglesby dark-blue Granite. One mile south of Oglesby, Elbert county, Georgia. Crossed nicols —x74.

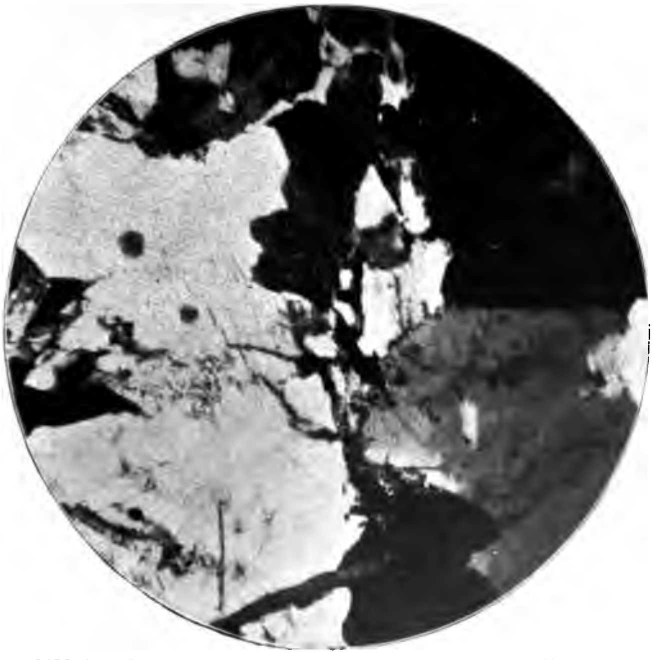

Plate XVIII. Figure 2. Photomicrograph of the Echol's Mill light-gray *Granite. Eleven miles northeast of Lexington, Oglethorpe county, Georgia.* Crossed nicols x74.

CHEMICAL ANALYSES OF THE OGLESBY-LEXINGTON DARK BLUE GRANITE.

	I	II	III	IV	V	VI	VII	VIII
SiO_2	70.38	70.30	70.18	70.03	69.74	69.64	69.53	69.36
Al_2O_3*	16.47	16.17	17.30	15.62	16.72	17.21	16.46	17.23
Fe_2O_3†	1.17	1.19	1.20	1.31	1.45	1.32	1.15	1.43
CaO	1.72	2.61	2.03	2.45	1.93	2.14	2.10	2.14
MgO	0.31	0.31	0.64	0.52	0.36	0.66	0.85	0.59
K_2O	5.62	4.88	4.77	5.42	5.33	4.95	4.91	4.57
Na_2O	4.98	4.72	4.36	4.82	4.84	4.53	5.00	5.17
Igni	0,31	0.63	0.35	0.77	0.47	0.35	0.91	0.33
Total	100.96	100.81	100.83	100.94	100.84	100.80	100.91	100.82

I. Biotite granite from Swift & Etheridge quarry, 4 miles west of Elberton, Georgia.

II. Biotite granite from Diamond Blue Granite Co.'s quarry, near Hutchins, Oglethorpe Co., Ga.

III. Biotite granite from Brown & Deadwyler quarry, Madison county, Georgia.

IV. Biotite granite from Lexington Blue Granite Co.'s Quarry, Lexington, Georgia.

V. Biotite granite from Coggin's Granite Co.'s quarry, near Oglesby, Elbert county, Georgia.

VI. Biotite granite from Coggin's Granite Co.'s quarry No. 2, near Oglesby, Georgia.

VII. Biotite granite from outcrops near Hutchins, Oglethorpe county, Georgia.

VIII. Biotite granite from the Child's quarry, near Oglesby, Georgia.

THE ELBERTON-ECHOL'S MILL LIGHT-GRAY GRANITE: This type is represented by a belt of approximately the same dimensions and general direction as the Oglesby-Lexington blue-gray granite, which it limits immediately on the southeast. The two areas are contiguous, and while well differentiated as to color, and in a less degree texture, in their extreme portions they undoubtedly form parts of the same general area, as the gradation is well shown near Elberton and Carlton.

The Elberton-Echol's Mill light-gray type does not differ essentially in mineralogy from the Oglesby-Lexington dark blue granite, although they are strongly contrasted in the hand specimens. The difference is essentially one of color, with the biotite distributed at greater intervals and in somewhat stouter aggregated shreds in the light-gray granite. As a rule, the light-gray type is slightly more coarsely crystalline than the dark-blue variety. The same minerals are present in nearly the same proportions and show the same characteristics in the two types. Quartz, orthoclase, microcline, plagioclase, biotite, a little muscovite, apatite and zircon are all present. [Pl XVIII, figure 2.]

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*Contains traces of P_2O_5, TiO_2 and ZrO_2 when present.

†All iron estimated as Fe_2O_3.

CHEMICAL ANALYSES OF THE ELBERTON-ECHOL'S MILL LIGHT-GRA GRANITE.

	I.	II.	III.
SiO_2	69.45	69.25	68.81
Al_2O_3	15.93	16.04	17.67
Fe_2O_3*	1.31	1.72	1.13
CaO	1.91	1.89	2.17
MgO	0.55	0.31	0.50
K_2O	5.16	4.94	3.90
Na_2O	4.33	4.52	4.97
Igni	0.50	0.43	0.30
Total	99.14	99.10	99.45

I. Biotite granite from Swift and Wilcox quarry, 1 mile south Elberton, Georgia.

II. Biotite granite from Tate and Oliver quarry in the limits Elberton, Georgia.

III. Biotite granite from Echol's Mill, 12 miles northeast from Lexi ton, Georgia.

THE CAMPBELL-COWETA-MERIWETHER COUNTIES' MEDIU BLUE-GRAY GRANITE: In addition to the normal massive gra ites, coarsely crystalline porphyritic granites and granit gneisses of essentially the same mineral and chemical compo tion, are found in intimate association over parts of Campbe Coweta and Meriwether counties.

The even-granular massive type of granite is of two vari ties. One, the medium gray, is an average fine-textured cry talline rock consisting of anhedra of an average size, 0.5-1 millimetres. [Plate XIX, figures 1 and 2.] The other, a dar blue-gray, occurs in the southwest section of Meriwether cou ty. [Plate XX, figure 1.] It is more coarsely crystalline a darker in color and contains a larger proportion of biotite, th the medium gray type.

The medium gray type traverses Campbell, Coweta a Meriwether counties, in a nearly north-south course, wi quarries opened near the respective county seats, Fairbur Newnan and Greenville. The variation in color and textu in general, is very slight. The northern part of the granit mass, in the vicinity of Fairburn, is somewhat lighter in colo with the middle and southern parts near Newnan and Gree ville, correspondingly darker. This type is closely similar mineral and chemical composition to the Oglesby-Lexingt

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* All iron estimated as Fe_2O_3.

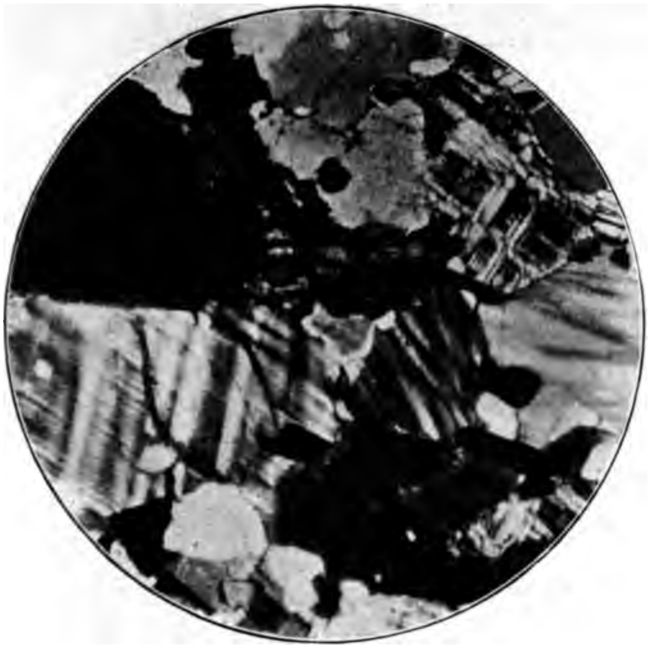

PLATE XIX. FIGURE I. PHOTOMICROGRAPH OF THE CAMPBELL-COWETA-MERIWETHER COUNTIES' MEDIUM BLUE-GRAY GRANITE. TWO MILES NORTH OF FAIRBURN, CAMPBELL COUNTY, GEORGIA. CROSSED NICOLS x74.

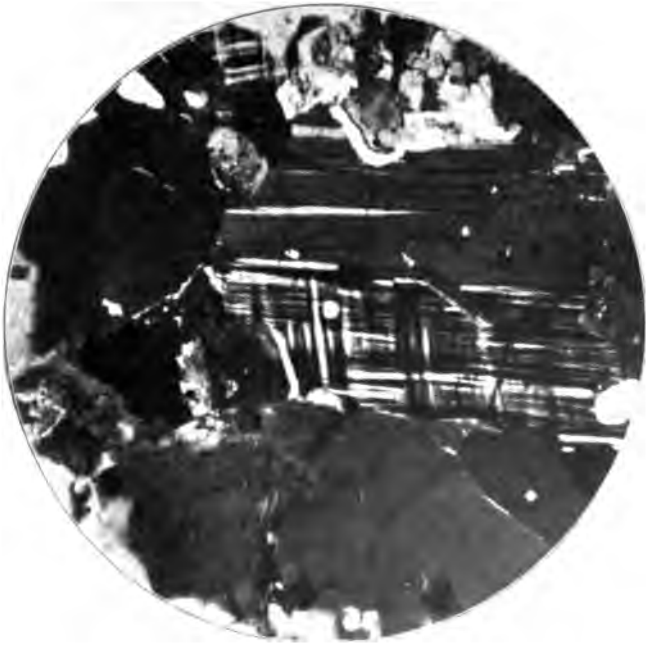

PLATE XIX. FIGURE 2. PHOTOMICROGRAPH OF THE GREENVILLE MEDIUM BLUE-GRAY GRANITE. GREENVILLE GRANITE COMPANY'S QUARRY, GREENVILLE, MERIWETHER COUNTY, GEORGIA. CROSSED NICOLS x74.

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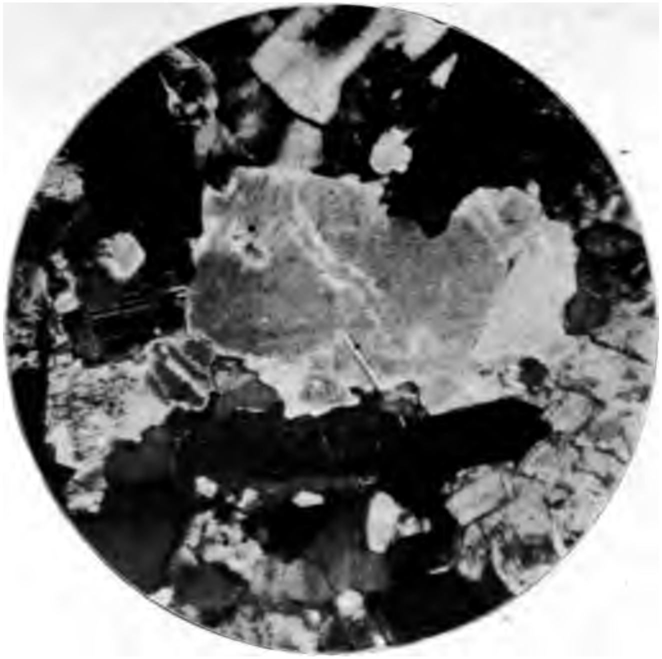

PLATE XX. FIGURE 1. PHOTOMICROGRAPH OF DARK-BLUE-GRAY GRANITE NEAR ODESSADALE, MERIWETHER COUNTY, GEORGIA. CROSSED NICOLS X74.

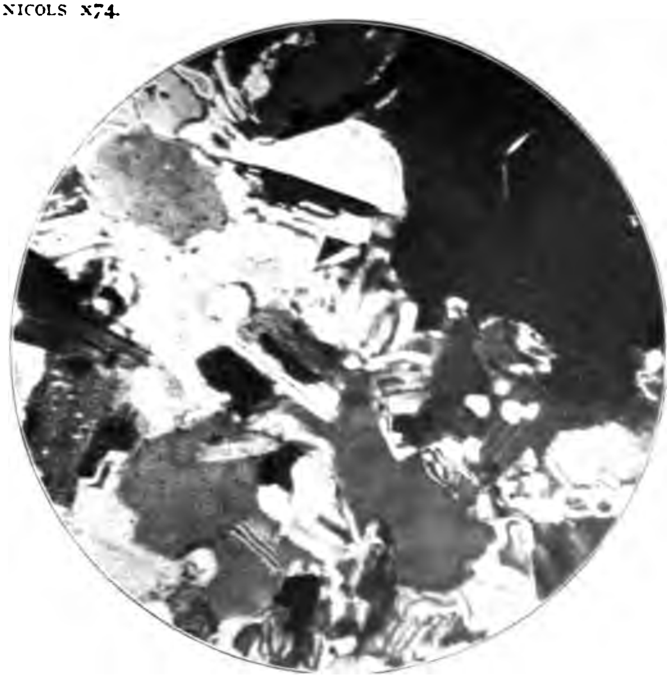

PLATE XX. FIGURE 2 PHOTOMICROGRAPH OF THE STONE MOUNTAIN LIGHT-GRAY GRANITE. STONE MOUNTAIN, DEKALB COUNTY, GEORGIA. CROSSED NICOLS X74.

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ue-gray, and the Elberton-Echol's Mill light-gray types, and intermediate in color and texture between the two latter vaeties. The component minerals are quartz, orthoclase, miocline, plagioclase near oligoclase, biotite, a little muscovite,)atite and zircon. Some secondary epidote and chlorite from e alteration of feldspar and biotite are usually present. Seval small garnets have been noted in one or two places in the)rthern part of the belt. The orthoclase is microperthitic in ructure and is the predominating feldspar. Microcline :arly fails in places and is very abundant in others. Plagioase is of the usual kind noted above. Rounded disks of micro:gmatitic intergrowths of quartz and feldspar are common. iotite is present in variable amounts intimately associated ith muscovite. Muscovite is always subordinate to biotite amount. The biotite is deep brown in color with strong ab-rption and variously altered to chlorite. Epidote, in the rm of irregular grains and idiomorphic crystals, is somewhat)undant in thin sections of the Cole quarry granite near ewnan. The increased percentage of lime in the analysis this rock corroborates the microscopic evidence (see analys I.)

IEMICAL ANALYSES OF THE COWETA COUNTY MEDIUM BLUE-GRAY GRANITE.

	I.	II.	III.
SiO_2	69.08	69.07	68.79
Al_2O_3*	17.67	16.56	16.48
Fe_2O_3†	1.41	1.37	0.98
CaO	3.27	1.83	1.76
MgO	0.64	0.76	1.30
K_2O	3.29	5.02	5.85
Na_2O	4.56	4.65	4.74
Igni	0.56	0.92	0.38
Total	100.48	100.18	100.28

. **Biotite granite from the Cole quarry, near Newnan, Georgia.**

. **Biotite granite from the Overby quarry, 10 miles northeast from Newnan, Georgia.**

. **Biotite granite from the Hill quarry, 3¼ miles southeast from Newnan, Georgia.**

The dark gray variety is more coarsely crystalline than the eceding and contains more biotite and perhaps more plagiose as a rule, with slightly less quartz. The specific gravity and chemical analysis given in table A, corroborate the above inferences. The component minerals are essentially the same, but in slightly varying proportions, as for the preceding types.

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* Contains traces of P_2O_5, ZrO_2 and TiO_2 when present.

† All iron estimated as Fe_2O_3.

THE STONE MOUNTAIN LIGHT GRAY GRANITE: The Stone mountain light gray variety is strongly contrasted with all other types of granite in the state. In mineralogy it differs only in the reversed proportion of biotite to muscovite, and is a biotite-bearing muscovite granite. Biotite is a constant accompaniment, but is greatly subordinated to muscovite in quantity. This type is uniformly light gray in color over the entire area, but shows some variation in texture, in places. It is intermediate in texture between the other types of normal granite on the one hand, and the coarsely crystalline granite matrix of the prophyritic granites on the other. As a rule, the Stone mountain type consists of anhedra ranging in size from 1.5-2.5 millimetres. [Plate XX, figure 2.] The potash feldspars predominate with orthoclase usually in excess of microcline. The orthoclase is commonly interwoven with a second feldspar in microperthitic structures. Microcline is subject to considerable variation in amount, at times, equaling that of the orthoclase in places, and sinking to a minimum in others. Plagioclase is only subordinate to the postash feldspars in amount, and occurs as stout laths with the characteristic polysynthetic twinning, lamellæ affording as a rule low extinction angles on the base. Quartz, in addition as irregular interstitial grains, is common in drop-like inclusions in the feldspars. Muscovite occurs either as individual flakes or aggregates with strong double refraction and often a faint yellowish tinge. The ray vibrating parallel to the cleavage shows appreciable absorption in many flakes. Biotite, as single foils with the usual pronounced color and absorption, is associated with the muscovite. Accessory apatite and zircon, and secondary chlorite, complete the list of microscopic minerals present. (See analysis I, table A.)

Several minerals not met in thin sections of the Stone mountain granite are frequent microscopic accompaniments in the rock. The most abundant one of these is black tourmaline. This mineral is present, in every block of stone quarried, in the shape of aggregated small prismatic crystals usually without terminal faces, embedded in a perfectly white irgular oval-shaped area of quartz and feldspar, from which ie two micas, muscovite and biotite, have been excluded. As rule, the white areas containing the tourmaline bunches are nly a fraction of one inch to several inches in diameter, though irger ones are by no means exceptional. Small crystals of ed garnet are not uncommon. The joint planes exposed in everal quarries on the north side of the ridge are coated with sulphur-yellow incrustation, which, upon chemical investiga-on, proved to be a mixture of uranophane and hyalite, with ie former in excess.

Approximately 12 miles southwest from Stone mountain n the same county, is a second exposure of a biotite-bear-ng muscovite granite, light gray in color and finely crystalline n texture. The rock has been used to some extent as a mon-imental stone. It consists of the same materials in the same roportions as the Stone mountain granite. Micropegmatitic ntergrowths of quartz and feldspar are common. The pris-natic inclusions of apatite in the quartz are frequently bent and roken, and, in some cases, the parts have slipped past each ther.

Some effects of strain are frequent in all the above types f granite, indicating that they have suffered from partial ynamic metamorphism. The microscopic evidence strength-ning this conclusion is undulatory extinction in the quartz; racture lines crossing the quartz and sometimes the larger eldspar anhedra; and somewhat increased microcline in laces, manifesting some evidence of a strained condition. In leriwether county, and several of the nearby counties, areas f rather pronounced foliated granites of the same mineral and hemical composition, resembling in other respects the massive hases, are found. The gradation, if such exists, between the nassive and foliated granites could not be satisfactorily traced n the field, in this area, but the laboratory evidence strongly avors such. If this be true, the traceable gradations in the ield are rendered impossible on account of few exposures and he very heavy covering of residual decay. In thin sections of he foliated rocks, the evidence of pressure metamorphism is ncreased in some peripheral shattering of the larger quartz nd feldspar individuals. Pressure metamorphism is further nade evident in the Stone mountain type in a slight pseudo-oliation.

(B) THE PORPHYRITIC GRANITES.

The porphyritic facies of the Georgia granites are elsewere described and discussed at some length by the writer.[*] The individual areas are described in detail and their relations to the normal granite facies stated. For the purposes of the present paper, it is only necessary to note their distribution and briefly describe them as a whole, detailing their chief characters so far as they bear on the present problem.

More than a half-dozen well-defined separate areas of coarsely crystalline porphyritic granites are noted within the limits of the Piedmont Plain of Georgia. In every case, they are associated with an even-granular facies of the same rock, having the same mineral and chemical composition. The porphyritic areas have been designated as follows: The Campbell-Coweta-Fayette counties' area: the Pike county area: the Fulton county area; the Brinkley place-Holder's Mill area; the Sparta area; the Milledgeville area; the Greene county area; the Columbia county area.

General Description: Certain general features are common to all the porphyritic areas, although the rocks are strongly contrasted in many. With one exception, they are all massive in structure, without, as a rule, trace of the primary or secondary foliated structure. The exception is in the Brinkley Place-Holder's Mill area, where the rock has a pronounced schistose structure, clearly due to pressure metamorphism. The porphyritic granites are prevailingly coarse-grained and light to dark gray in color, according to the amount of biotite present.

PETROGRAPHY.

The groundmass or matrix is a typical coarse biotite granite without the foliated structure. It consists of anhedra measuring 3 to 8 millimetres in size. [Plate XXI, figures 1 and 2.] The principal minerals are quartz, orthoclase, microcline, plagioclase, biotite, a little muscovite, apatite and zircon. Some chlorite and epidote derived from the alteration of the feldspar and biotite occur. Quartz is abundant and the feldspars have the same general characters as in the even-granular types of

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[*] *Journal of Geology*, 1901, vol. ix, February-March number. A Preliminary Report on the Granites and Gneisses of Georgia, *Geol. Sur. of Ga.*, in press.

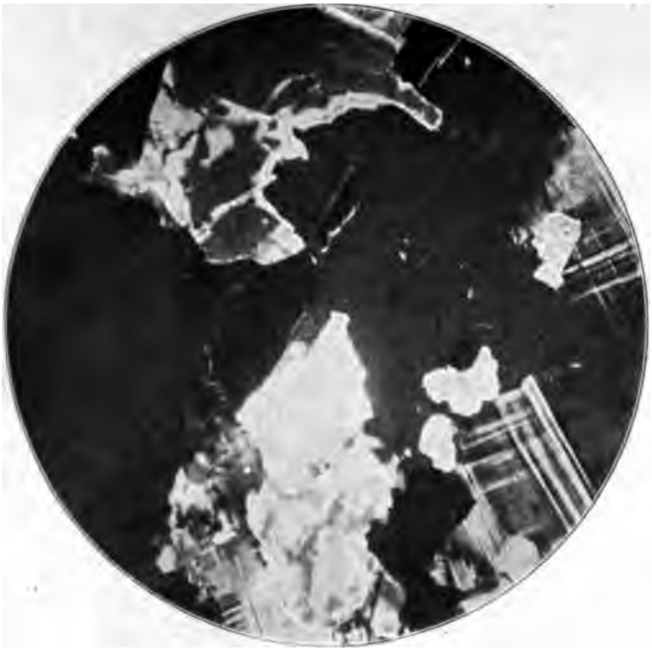
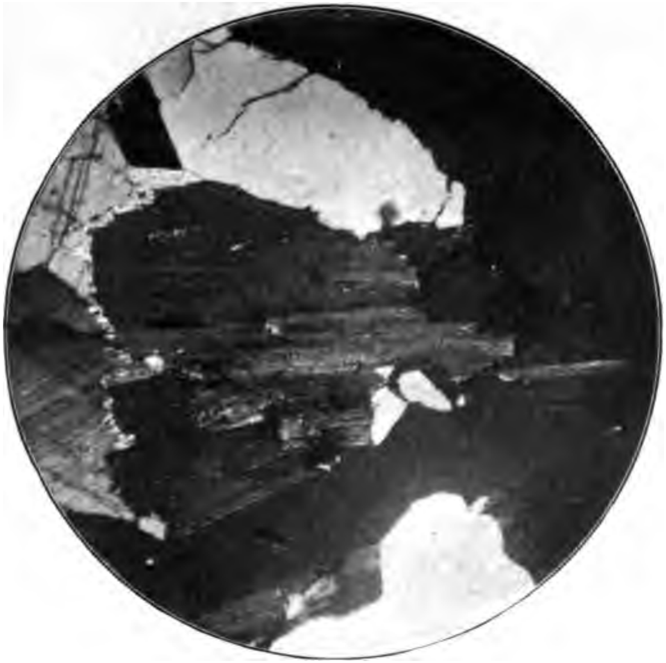


PLATE XXI. FIGURE 1. PHOTOMICROGRAPH OF PORPHYRITIC GRANITE TEN MILES SOUTH OF GREENESBORO, GREENE COUNTY, GEORGIA. CROSSED NICOLS x74.



LATE XXI. FIGURE 2. PHOTOMICROGRAPH OF PORPHYRITIC GRANITE NEAR COWETA STATION, COWETA COUNTY, GEORGIA. CROSSED NICOLS x74.

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granite described above. Microcline is possibly subject to more variation than in the normal granites, and plagioclase is, as a rule, slightly increased. The feldspars are usually white opaque in color, with greenish-white and pink tints not uncommon. The interstitial feldspar is transitional into the phenocrysts in several areas. The quartz frequently crystallized simultaneously with the feldspars, resulting in the formation of ovals of micropegmatitic structures, common in the thin sections from all the areas. Biotite is variable in amount but occurs in stout plates, deep brown in color and strongly pleochroic. Apatite is very abundant in the form of stout prismatic inclusions in some slides and almost fails in others.

The phenocrysts are usually opaque and white in color with pink tints common. They vary from 10-50 millimetres long and 5-10 millimetres across; and vary from allotriomorphic to idiomorphic in crystal outline. The idiomorphic type prevails, however; flat, tabular parallel to the clinopinacoid (010), with (001) and (101) cleavages well developed. They display the usual habit of simple Carlsbad twins. Only the potash varieties, orthoclase and microcline, are porphyritically developed, and, as a rule, are intergrown with a second feldspar in microperthitic fashion. They invariably contain inclusions of all the groundmass minerals, which with other evidence, indicates simultaneous growth with the interstitial components. The inclusions of biotite plates are always macroscopic in size and, in many cases, the included mica is equally large as the same interstitial mineral. The IN PLACE as against INTRATELLURIC origin for the phenocrysts has been elsewhere pointed out.

Analyses of carefully selected fragments of the feldspar phenocrysts from two of the areas yielded the following results:

	I.	II.	
SiO_2	64.64	64.40	
Al_2O_3	19.64	18.97	
Fe_2O_3	0.37	0.37	
CaO	0.67	0.59	
MgO	tr.	tr.	
K_2O	10.00	11.40	
Na_2O	3.06	3.60	
Ignition	0.22	0.19	
Total	98.60	99.52	
Sp. Gr.	2.60	2.55	(Thoulét solution.)

I. Feldspar phenocrysts from Columbia Co. porphyritic granite mass.
II. " " " Coweta " " " "

(See analyses IX, X, XI, XII, XIII, XIV, and XV of Table A.)

Gradation from the porphyritic facies, peripherally, into a medium coarse-textured non-porphyritic granite facies of the same mineral and chemical composition is traceable in some of the areas. The lack of field evidence favoring gradation in the other areas is probably due to absence of exposures. As a rule, the rocks in the Georgia area, as well as in the southern states in general, are covered by a heavy mantle of residual decay, and exposures of fresh rock are limited and by no means continuous.

(C) THE GRANITE-GNEISSES.*

Extensive areas of gneiss of granitic composition abound in the Piedmont Plain, and in abundance, becomes one of the most, if not the most important rock in the plateau-complex. The gneisses vary from medium to coarsely crystalline rocks with a pronounced banded or schistose structure. The planes of schistosity vary from moderately irregular to highly contorted lines with the banding exceedingly irregular; from very thick to very thin layers. They are closely related genetically to the massive granites from which they differ only in the banded structure, secondarily imparted through dynamo-metamorphism. The two types—gneisses and massive granites—are essentially alike in mineral and chemical composition. The minerals found in one are invariably present in the other. Furthermore, the minerals most abundant in the one also predominate in the other. Like the massive granites, the acid gneisses are all biotite gneisses. Muscovite is an invariable associate but is subordinated in every case to the biotite in quantity; and hornblende is never present. The acid gneisses studied are believed for these and other reasons stated later, to be metamorphosed irruptive granites and are therefore designated granite-gneisses.

Separate descriptions of the individual areas can not be detailed here, but instead, several of the larger and representative ones will be briefly described as illustrating their composition.

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* There may be and probably are gneisses of sedimentary origin in the Plateau-crystalline-complex, but the areas of gneiss so far studied afford no evidence of such origin. The discussion is entirely limited to those areas studied.

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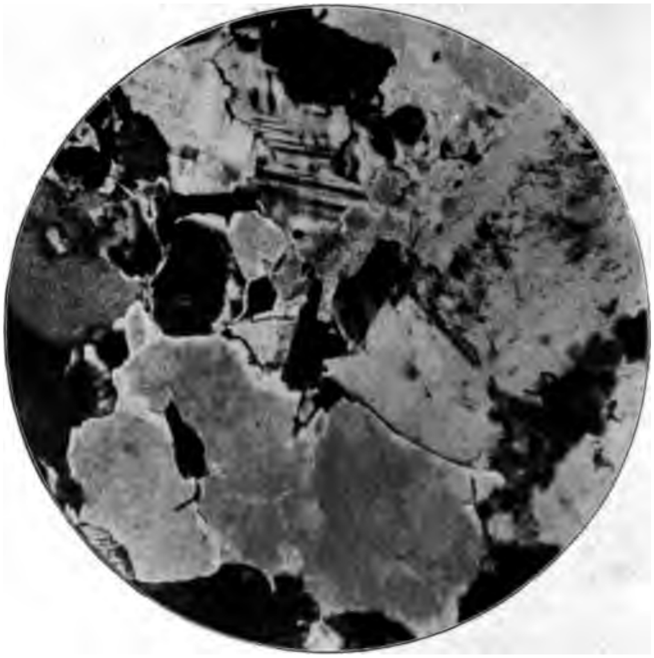

PLATE XXII. FIGURE 1. PHOTOMICROGRAPH OF THE LITHONIA CONTORTED BIOTITE GRANITE-GNEISS NEAR LITHONIA, DEKALB COUNTY, GEORGIA. CROSSED NICOLS X74.

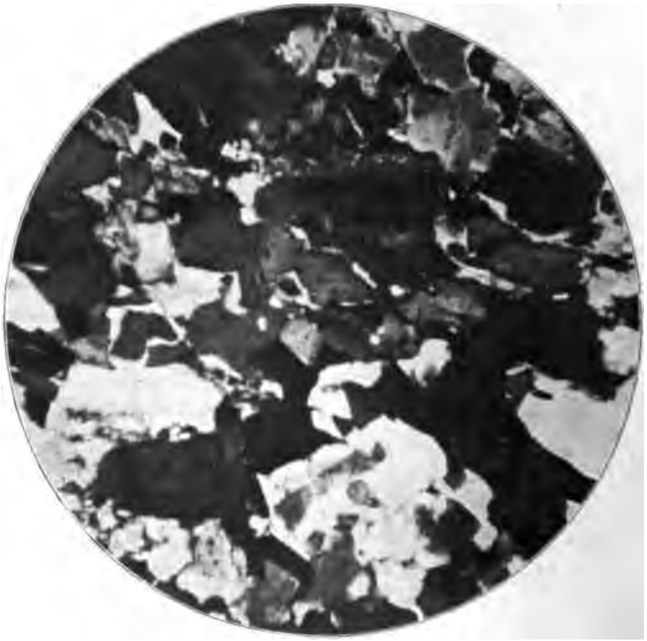

PLATE XXII. FIGURE 2. PHOTOMICROGRAPH OF A FINE-GRAINED DARK-BLUE BIOTITE GRANITE FROM A DIKE FORTY FEET WIDE, CUTTING THE PORPHYRITIC GRANITE-GNEISS, NEAR CAMAK, WARREN COUNTY GEORGIA. CROSSED NICOLS X74.

THE LITHONIA BELT OF CONTORTED GNEISS: The Lithonia belt of gneiss is continuous over a large part of three contiguous counties, and lies immediately adjacent on its north and west sides to the famous Stone mountain light-gray granite area. The belt takes its name from the town of Lithonia, located near the centre of the quarrying industry. The rock has been quarried very extensively as blocks and curbing for street paving, and has been shipped to the principal cities in the south and middle west.

It is an irregularly banded, highly contorted, biotite granite-gneiss, medium light-gray in color, and composed of anhedra ranging in size from 0.5-2.5 millimetres. [Plate XXII, figure 1.] The principal minerals are quartz, orthoclase, microcline, plagioclase, biotite, a little muscovite, apatite, zircon and magnetite. Some secondary chlorite, epidote, kaolin and muscovite occur. Idiomorphic crystals of red garnet are very common in some of the quarries. The garnets form in some cases distinct lenses and layers alternating with bands of the principal minerals, and are also scattered as single crystals through the rock. Small areas of black tourmaline are distributed in a similar manner through the granite-gneiss to that of the Stone mountain granite, with the exception that the areas are by no means so frequent in the former rock as in the Stone mountain type.

Orthoclase is the predominating feldspar and in part is microperthitic in structure. Microcline is subject to much variation with a general average increase, somewhat larger for the gneisses than for the granites. The increase in this constituent in the foliated granitic rocks over the massive types can probably be accounted for on the basis of pressure metamorphism, as numerous pieces of the mineral show some indications of a possible induced structure, such as might result from excessive strain. A large percentage of this constituent however, is undoubtedly primary in origin, while the remainder is somewhat doubtful. Plagioclase is also variable in amount and is present in the form of stout laths with characteristic polysynthetic twinning, affording small extinction angles in basal sections. Biotite, as deep brown-colored and strongly pleochroic foils, is drawn out along roughly parallel lines. It is associated with smaller amounts of muscovite, and, as a rule, carries microscopic inclusions. Quartz, with occasional grains of feldspar, are common in drop-like inclusions in the larger feldspar individuals. Micropegmatitic intergrowths of quartz and feldspar do not fail entirely in thin sections of the granite-gneiss, but are less frequently met than in the massive granites.

A second area of similar highly contorted gneiss begins in Troup county in middle southwest Georgia near the Alabama line, and crosses Meriwether county in an east-west course. Hand specimens of the rock from the two areas are indistinguishable and are identical in mineral and chemical composition.

The other areas of gneiss are strongly contrasted, and vary in degree and regularity of the foliated structure, and in color and texture. The relationships, while not entirely clear in the field, possibly suggest that several of the areas may be the transitional foliated phases of the massive granites, but so far as the writer's observations extend, the conditions strongly point to no gradation of the typical gneisses into the equivalent massive rocks. They are all, however, biotite granites with the same minerals present in nearly similar proportions. This fact is further corroborated in the table of analyses where the rocks are seen to be nearly identical in composition. (See analyses XVI, XVII, XVIII, XIX, XX, XXI, XXII, and XXIII Table A.)

That the schistose or foliated structure is entirely secondary, resulting from pressure metamorphism, and not primary, is plainly manifested in the thin sections of these rocks. The quartz and feldspar grains are invariably rimmed by crushed zones of the two minerals; the quartz extinguishes irregularly; and numerous lines of fracture are common to both quartz and feldspar. The Lithonia area of contorted gneiss, however, affords but slight if any evidence of peripheral shattering, which likely indicates recrystallization of the minerals through profound metamorphism.

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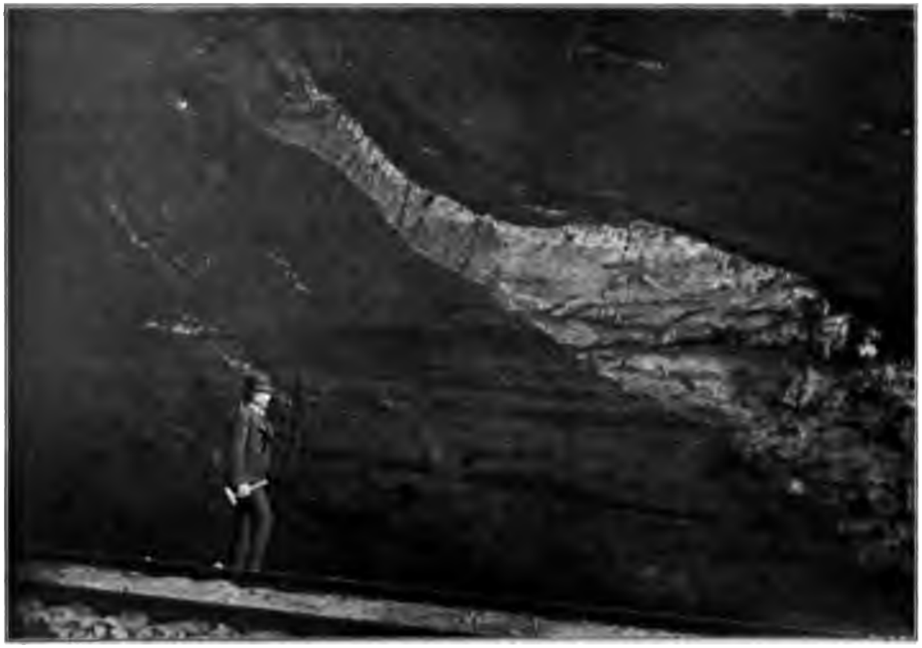

PL. XXIV. [illegible] GRANITE DIKE CUTTING MICA SCHIST NEAR ATLANTA, GEORGIA.

CHEMICAL ANALYSES OF THE LITHONIA CONTORTED GRANITE-GNEISS, DEKALB COUNTY.

	I.	II.	III.
SiO_2	76.00	75.16	72,96
Al_2O_3	13.11	13.74	14.70
Fe_2O_3*	0.92	0.91	1.28
CaO	1.06	0.91	1.28
MgO	0.27	0.17	0.07
K_2O	4.69	5.05	4.73
Na_2O	3,88	3.76	4.18
Ign..	0.31	0.32	0.23
Total	100.24	100.02	99.43

I. Biotite granite-gneiss from the Crossley quarry, near Lithonia, Georgia.

II. Biotite granite-gneiss from the Arabia Mountain quarries 3 miles from Lithonia, Georgia.

III. Biotite granite-gneiss from the Southern Granite Co.'s quarry, near Lithonia, Georgia.

Intrusive nature of the granites.

The evidence of the igneous origin of the Georgia granites is essentially the same as for similar irruptive acid masses studied elsewhere. The evidence is from, (1) field relations; (2) chemical composition; and (3) mineral composition,

1. Field relations.

STRATIGRAPHIC FEATURES: The exposures of the granites in the field point to rounded or elliptical forms common to intruded granite masses. The two granite facies—porphyritic and non-porphyritic—may be considered as one, since in many of the granite areas the porphyritic structure grades peripherally, into a non-porphyritic granite facies of the same mineral and chemical composition, and are from necessity of the same origin. In the case of the foliated phases of the granites, the schistosity is not co-incident with that of the surrounding schist, but cuts across the foliation of the latter.

Near many of the larger granite-masses well-defined granite dikes, slightly different in texture from, but of the same mineral and chemical composition as the mass, occur, which would commonly be regarded as apophyses in case the rock is regarded as eruptive. [Plate XXIV.] These dikes or apophyses project outward from the main rock-mass and cut abruptly into the adjacent rocks. A chemical analysis of specimens collected from a 40-foot dike cutting the porphyritic granite-gneiss near Camak on the Brinkley place, yielded the writer the following results:

---

* All iron estimated as Fe_2O_3.

SiO_2	68.76
Al_2O_3	16.80
Fe_2O_3	0.99
CaO	2.72
MgO	1.00
Na_2O	4.82
K_2O	3.70
Ignition	0.29
Total	99.08

A comparison of this analysis with analyses of the normal even-granular granites reveals practically no difference. The acidity, as will be observed, is essentially the same.

In addition to the quartz, feldspar varieties and biotite, thin sections showed inclusions of apatite and zircon, and drop-like inclusions of quartz and feldspar grains in the larger feldspar individuals, along with rounded disks of micropegmatitic intergrowths of quartz and feldspar. [Plate XXII, figure 2.]

CONTACT PHENOMENA: In all cases where contacts of the granitic rocks and schists were visible, they were, in the opinion of the writer, plainly eruptive. Although many contacts have been examined, they are not so numerous as might be expected, on account of the deep covering of residual decay. The line of contact is usually sharp and somewhat irregular in the localities where best exposed. No considerable contact metamorphism of the surrounding rocks was visible, however, in any exposure. Since the surrounding rocks are equally completely crystalline, as a result of profound metamorphism, any considerable alteration would hardly be expected. Many granite intrusions into crystalline rocks showing little or no contact metamorphism have been observed in different localities by various writers. None of the commonly associated minerals of contact phenomena are present in the sections examined. In some areas, garnets, and tourmaline are very common, but their occurrence is as frequent away from the contact as near it, and cannot be considered a result of contact metamorphic action between the rocks. In no case has any definite gradation from the acid rocks into the schists been observed in the field [illegible] that appear strongly differentiated.

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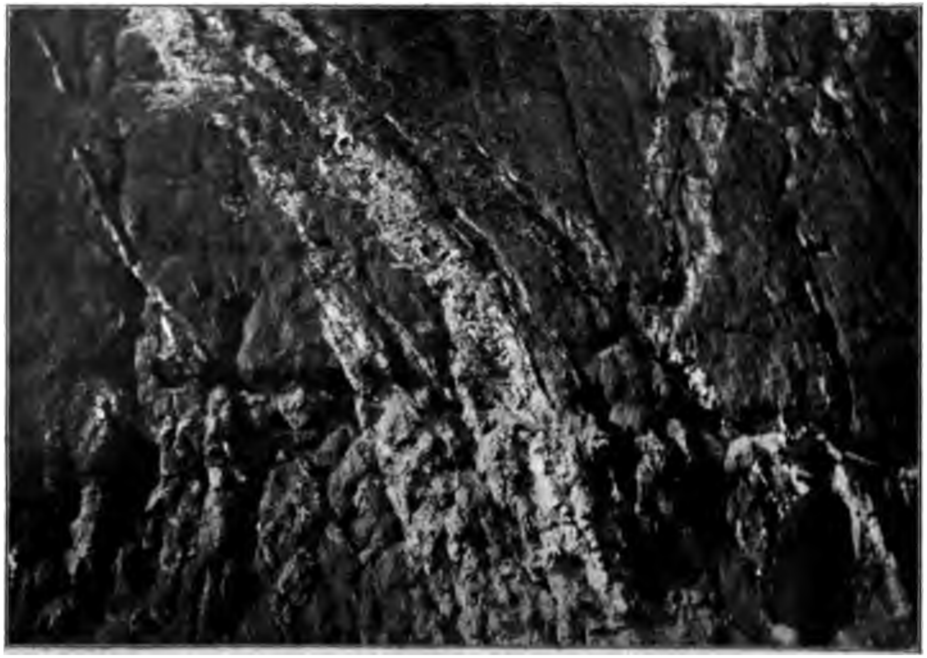

PLATE XXIII. PEGMATITIC DIKES CUTTING MICA SCHIST NEAR ATLANTA, GEORGIA. THE INCLOSING SCHISTS ARE WEATHERED TO A FERRUGINOUS RESIDUAL CLAY IN WHICH THE SCHISTOSITY PLANES OF THE FRESH ROCK ARE WELL PRESERVED.

BASIC INCLUSIONS: Another form of evidence strongly oring the irruptive nature of the granitic rocks is that of usions darker in color and considerably more basic in char- r than the parent rock, met in many of the masses. It has been possible to distinguish in every instance between in- ions of the inclosing rock and that of darker material— ieren—basic segregations of the granite magma. In the ority of cases, the darker areas plainly represent basic seg- ations, which form so common a feature of slowly solidify- granite magmas. They are especially abundant in many he quarries; are darker in color than the parent granite and sist chiefly of biotite with subordinate quartz, orthoclase, gioclase and apatite, with no evidence of foliation. They are nded and irregular in outline and, in case of the gneisses, n lenticular patches and bands in extreme cases. As a rule, are finer-grained in texture than the inclosing rock, but in e cases they are coarser crystalline. Inclusions of this racter are regarded by many writers* as strong evidence of eruptive origin of the rocks in which they are found.

PEGMATITIC DIKES: Closely associated pegmatitic dikes varying width and granitic composition are numerous oughout the Plateau-crystalline complex, and are unques- ably genetically connected, in many cases, with the granite- ses. They vary from those of granitic composition to e quartz. Under this heading two kinds of material are . Some are true pegmatitic intrusions, while others are veins of segregation. Both are common to the porphyritic non-porphyritic granite facies and to the gneisses, and are ally characteristic of each. They are characterized by the al coarse-grained structure and consist almost exclusively ustrous, cleavable pink and white-tinted feldspar with some rtz, and a much smaller proportion of biotite, and occasional scovite. [Plate XXIII.] In many cases they are very exten- and deep-seated, while in others they are very limited in nt and are entirely surrounded by the granitic rock. They very irregular in outline, conforming to no uniform orien- on, but cut the rock in numerous directions and at various

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ROSENBUSCH, MASSIGE GESTEINE, p. 62.
ILLIAMS, G. H., *15th Annual Report*, U. S. G. S., p. 662.
EMP, J. F., *Bull. Geol. Soc. Amer.*, 1899, vol. x, pp. 371-372.
ESTGATE, L. G., *Journ. of Geol.*, 1899, vol. vii, p. 643.

angles. Thin sections of several of these masses show microcline, orthoclase and plagioclase feldspars, with occasional microperthitic structures, a few shreds of biotite and some quartz. Hand specimens of others showed nearly equal proportions of feldspar and quartz with occasional biotite plates.

2. CHEMICAL COMPOSITION.

The following analyses give a good idea of the range in composition of the granitic rocks described above. These analyses present several points of interest, chief among which may

A. TABLE OF CHEMICAL ANALYSES.

GRANITES.

	I Stone Mt.	II† Lexington	III Greenville	IV‡ Oglesby	V Campbell county	VI§ Elberton	VII‖ Coweta county	VIII Meriw'r county
SiO_2	72.56	69.95	69.88	69.86	69.55	69.17	68.98	63.27
Al_2O_3'	14.81	16.08	16.42	16.98	16.72	16.54	16.90	19.93
Fe_2O_3*	0.94	1.21	1.96	1.31	0.99	1.38	1.25	2.82
CaO	1.19	2.38	1.78	1.99	1.69	1.99	2.28	2.89
MgO	0.20	0.56	0.36	0.51	0.27	0.45	0.90	0.49
K_2O	5.30	5.07	5.63	5.04	3.94	4.66	4.72	4.85
Na_2O	4.94	4.84	4.45	4.77	5.88	4.60	4.98	4.14
Igni.	0.70	0.77	0.39	0.36	0.27	0.41	0.62	0.86
Total	100.64	100.86	100.87	100.82	99.31	99.20	100.63	99.25
Sp. Gr.	2.684	2.666	2.662	2.663	2.658	2.656	2.694	2.739

PORPHYRITIC GRANITES.

	IX Fayette County	X Pike County	XI Columbia County	XII Baldwin County	XIII¶ Sparta	XIV Fulton County	XV Greene County
SiO_2	70.38	70.24	69.77	69.37	69.33	69.17	69.13
Al_2O_3'	15.86	16.78	17.05	16.99	16.26	16.47	17.14
Fe_2O_3*	1.77	1.46	1.60	1.99	1.84	1.23	1.52
CaO	1.79	2.00	2.21	2.03	2.28	2.02	1.85
MgO	0.93	0.76	0.99	0.84	0.36	0.61	0.79
K_2O	4.64	5.03	4.08	4.54	4.56	4.41	5.49
Na_2O	3.94	3.70	3.97	3.44	5.07	4.89	4.06
Igni.	0.49	0.50	0.44	0.55	0.42	1.06	0.52
Total	99.80	100.47	100.11	99.75	100.12	99.86	100.50
Sp. Gr.	2.659	....	2.674	....	2.675	....	....

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* All iron estimated as Fe_2O_3.

† Average of 3 analyses representing different quarries.

‡ " " 5 " " " "

§ " " 3 " " " "

‖ " " 3 " " " "

¶ " " 3 " " " "

' Contains traces of P_2O_5, TiO_2 and ZrO_2 when present. With several exceptions, the usual qualitative test failed to indicate the presence of TiO_2 in the Georgia acid rocks. P_2O_5 and ZrO_2 are invariably present in small microscopic proportions as prismatic inclusions of apatite and Zircon.

GNEISSES.

XVI	XVII	XVIII	XIX	XX°	XXI	XXII	XXIII
Meriw'r County	Gwinnett County	Rockdale County	Heard County	Lithonia	Coweta County	Newton County	Clarke County
76.37	75.86	75.45	74 96	74.70	73.95	71.20	69.51
13.31	14.02	13.71	13.71	13.85	14.23	15.46	16.32
1.21	0.71	0.92	0.90	1.03	1.29	1.17	2.38
1.13	0.70	0.94	1.02	1.08	1.07	1.36	1.84
0.10	0.12	0.18	0.24	0.17	0.23	0.38	1.28
3.68	5.56	4.30	4.79	4.82	5.29	5.30	3.47
4.02	3.64	3.87	4.68	3.94	4.61	4.96	3.82
0.20	0.28	0.40	0.44	0.28	0.25	0.52	1.11
100.02	100.89	99.77	100.74	99.87	100.92	100.30	99.73
2.642	2.642	2.643	2.648	2.686	....	....	....

B. MOLECULAR RATIOS OF THE OXIDES.

GRANITES

I	II	III	IV	V	VI	VII	VIII
1.209	1.165	1.164	1.164	1.159	1.152	1.149	1.054
.145	.156	.160	.164	.163	.160	.164	.195
.005	.007	.012	.008	.006	.008	.007	.017
.021	.042	.032	.035	.030	.035	.040	.051
.005	.014	.009	.012	.006	.011	.022	.012
.056	.053	.059	.053	.041	.049	.050	.051
.079	.078	.071	.076	.094	.074	.080	.066
.135	.131	.130	.129	.135	.123	.130	.117

PORPHYRITIC GRANITES

IX	X	XI	XII	XIII	XIV	XV
1.181	1.170	1.162	1.156	1.155	1.152	1.152
.155	.164	.167	.166	.157	.163	.168
.011	.009	.010	.012	.011	.007	.009
.032	.035	.039	.036	.040	.036	.033
.023	.019	.024	.021	.009	.015	.019
.049	.053	.043	.048	.048	.047	.058
.063	.059	.064	.055	.081	.078	.065
.112	.112	.107	.103	.129	.125	.123

GRANITE—GNEISSES

XVI	XVII	XVIII	XIX	XX	XXI	XXII	XIII
1.272	1.264	1.257	1.249	1.245	1.232	1.186	1.158
.130	.137	.134	.134	.134	.139	.151	.160
.007	.004	.005	.005	.006	.008	.007	.014
.020	.012	.016	.018	.019	.019	.024	.029
.002	.003	.004	.006	.004	.005	.008	.010
.039	.059	.045	.050	.051	.026	.056	.044
.064	.058	.062	.075	.063	.074	.080	.070
.103	.117	.107	.125	.114	.110	.136	.114

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iron estimated as Fe_2O_3.

erage of 3 analyses representing different quarries.

ntains traces of P_2O_5, TiO_2 and ZrO_2 when present. With sever-
ptions, the usual qualitative test failed to indicate the presence
in the Georgia acid rocks. P_2O_5 and ZrO_2 are invariably present
microscopic proportions as prismatic inclusions of apatite and

No. of Anal.	$K_2O : Na_2O$	
I	1 : 1.41	GRANITES.
II	1 : 1.47	
III	1 : 1.20	
IV	1 : 1.43	
V	1 : 2.29	
VI	1 : 1.51	
VII	1 : 1.60	
VIII	1 : 1.29	

No. of Anal.	$K_2O : Na_2O$	
IX	1 : 1.28	PORPHYRITIC GRANITES.
X	1 : 1.11	
XI	1 : 1.49	
XII	1 : 1.14	
XIII	1 : 1.68	
XIV	1 : 1.65	
XV	1 : 1.12	

No. of Anal.	$K_2O : Na_2O$	
XVI	1 : 1.64	GRANITIC GNEISSES.
XVII	1 : 0.98	
XVIII	1 : 1.37	
XIX	1 : 1.50	
XX	1 : 1.23	
XXI	1 : 3.07	
XXII	1 : 1.42	
XVIII	1 : 1.59	

be mentioned their marked uniformity or very close agreement throughout for the three rock phases. A distinguishing feature is their relatively high percentage of Na_2O, which is observed to be above the average for normal granites. The percentages of Na_2O and K_2O approximate nearly equal amounts in a majority of the analyses, but in many the K_2O exceeds the Na_2O, while in others the Na_2O is in considerable excess over the K_2O. The high Na_2O in the Georgia granites is traceable to three sources: (1) the presence of comparatively appreciable amounts of single laths of an acid plagioclase; (2) the abundance of microperthitic intergrowths of the potash feldspars with a second feldspar, probably albite; and (3) in the potash feldspar varieties, a part of the potassium is replaced by sodium. See analysis on page 209. The general high range in total alkalies—Na_2O+K_2O—is a very noteworthy feature in the analyses. The general average for total alkalies is from 8.79 per cent. in the gneisses to 9.44 per cent. in the granites.

For the sake of ready comparison the following percentages obtained from the average of 21, 10 and 12 analyses, respectively, of the normal granites, porphyritic granites and granite-gneisses are hereby tabulated:

	SiO_2	Al_2O_3	Fe_2O_3	MgO	CaO	Na_2O	K_2O
Normal granites	69.67	16.63	1.28	0.55	2.16	4.73	4.71
Porphyritic granites	69.28	16.73	1.75	0.72	2.13	4.33	4.59
Granite-gneisses	73.76	14.52	1.03	0.29	1.14	4.16	4.63

No appreciable difference is noted in any one of the seven constituents in case of the normal granites and their equivalent porphyritic facies, but a comparison of the analyses of the granite-gneisses with those of the granites, discloses several interesting differences among the more important constituents. An increased percentage of about 4 per cent. in the SiO_2, and somewhat regular corresponding decreased percentages in the

Al_2O_3 and CaO, and to a less degree in the Fe_2O_3 and MgO over the two granite facies, are shown in the granite-gneisses; while the alkalies—$Na_2O + K_2O$—remain very uniform and constant for the three rock phases.

It will be further observed from an examination of the table of individual analyses, that with one or two exceptions the Georgia granitic rocks are normally acid granites, showing a general average of approximately 70 per cent. in SiO_2, while the percentages of iron and magnesia are somewhat below the general average for normal granites.

The molecular ratios of the oxides given above show a tendency in the Al_2O_3, Fe_2O_3 and CaO to gradually increase as the SiO_2 decreases for the three rock phases. The gradual rise in Al_2O_3 with decreasing SiO_2 is well illustrated in the case of the granite-gneisses. The table of molecular proportions further shows the alkalies in sum total remain fairly constant with only slight variation.

These statements would seem to indicate, that no absolute relation exists between the Al_2O_3, SiO_2 and alkalies, since the tendency is for the Al_2O_3 to increase as the SiO_2 decreases, while the $Na_2O + K_2O$ remain approximately the same.

3. MINERAL COMPOSITION.

From the preceding descriptions, the Georgia granitic rocks are seen to be made up of mixtures of the essential minerals, quartz, feldspar and biotite, with varying amounts of muscovite intimately associated with the biotite. The potash feldspar varieties predominate; and, in two cases, biotite is subordinated to muscovite. The entire absence of hornblende in these rocks is a marked feature. Besides these, the usual accessory minerals common to granite rocks in general, occur, and have already been mentioned. The relative proportions of the essential minerals in the granites, excepting the Stone mountain type, may be expressed thus: Feldspar including all varieties present > quartz > biotite > muscovite. For Stone mountain the proportions become: feldspar > quartz > muscovite > biotite.

There is nothing especially noteworthy about the bulk of the minerals present in the Georgia acid rocks, and therefore, they do not require extended details further than given under the descriptions of the various granite-types. There are several minerals present, however, which from their association and conditions of environment require further descriptions. These are microcline and muscovite.

The prevalence of intergrowths with a second feldspar common to the three rock phases, in case of orthoclase and to some degree microcline, in the form of microperthitic structures, has already been remarked on under the descriptions of the individual types.

MICROCLINE: The abundance of feldspar grains showing the characteristics cross-grating structure is a striking feature in most thin sections of the Georgia granites. The twinning lamellæ thin out in many cases, and do not always show perfectly parallel sides. Crystals are often met in which the microcline structure is developed in only a part of the individual and entirely failing in the other parts, leaving the untwinned area optically indistinguishable from orthoclase. These granites have been subjected, as elsewhere shown, to intense dynamometamorphism, which fact, coupled with the prevalence of this feldspar, affords strong indications of a part of this mineral having acquired its structure. A part of the microcline is unquestionably primary. Similar conditions are recorded in granite masses in different localities by various writers.*

MUSCOVITE: Since the occurrence of primary muscovite in an eruptive granite has been questioned, it is of interest to note a similar occurrence of this constituent in many of the Georgia granites to that observed by Keyes† in some of the Maryland granites, where primary origin affords the best explanation. In many of the Georgia granite areas, especially the Oglesby-Lexington dark blue granite area, large and sharply bounded plates of fresh appearing muscovite, are distributed through the rock in intimate association with the biotite. The two micas are frequently grouped together as aggregates in which the individuality of the separate crystals is well preserved. They not infrequently form parallel intergrowths, and at times the distinctly bounded muscovite plates penetrate and cut across the biotite foils at various angles. The relations of the two micas to each other, very strongly point to contemporaneous crystallization of the two minerals. The large shreds of supposed primary muscovite are in marked contrast in the same section to the muscovite of known secondary origin associated with kaolin, and resulting from feldspathic alteration. The cleavage lines are less distinct, and the muscovite presents greater irregularity of outline in case of the mineral of secondary origin. Still another portion of the muscovite in a part of the Georgia rocks has developed as a result of dynamometamorphism, and it is not always easy to distinguish between this and the same supposed primary constituent.

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* KEYES, C. R., *15th Ann'l Rept., U. S. G. S.*, 1893-94, pp. 711-712.
VON RINNE, NEUES JAHRB, ii, 1890, pp. 66-70. } Quoted by Keyes.
BEUTELLR, ZEITSCHR. f. Kryst, viii, p. 373. } Quoted by Keyes.
SAUER & USSING, Ibid, xviii, 1891, p. 196. } Quoted by Keyes.
BROGGER, Ibid, xvi, 1890, p. 561. } Quoted by Keyes.

† KEYES, C. R., *15th Ann'l Rept., U. S. G. S.*, 1893-94, pp. 703-704.

The marked similarity in mineral composition of the granites and gneisses is plain from the above descriptions. No mineral is found in one, that does not occur in the other; and those minerals most abundant in one predominate in the other. Their mineral composition conforms in every essential to that of known igneous granites occurring elsewhere. They are composed of minerals which most commonly make up the masses of normal eruptive granite. Not a single mineral among the list of primary and essential ones are included in the three rock phases, that does not characterize an igneous granite. The essential minerals are present furthermore, in the usual proportions common to such rocks. The rock types studied are entirely free from such minerals as staurolite, andalusite, cordierite and kyanite, frequently characteristic of sedimentaries. Garnet is sparingly present in some of the granites and becomes very abundant, in places, in a part of the gneisses, but it is unquestionably, in these cases, a product of metamorphism, and is as readily produced by such action, in igneous rocks, as in sedimentaries.

Hardly without exception, the thin sections of these rocks disclose an abundance of ovals or rounded disks of micropegmatitic structures—intergrowths of feldspar and quartz—which from their nature, in this case, are unquestionably referred to a primary product of the magma, and therefore represent simultaneous crystallization of the quartz and feldspar.

WEATHERING: Not only are the three phases of granitic rock alike in the above respects, which are in accord with similar rocks of igneous origin, but the form and manner of weathering are those of igneous rocks. The more perfectly banded phases,—gneisses—weather in process and topographic outline closely similar to the massive granites. The chemical and physical processes involved in the disintegration and decomposition of these rocks are the same, and are described and discussed elsewhere.*

RÉSUMÉ: From the preceding facts, there can apparently be little question as to the origin of the granites and their banded equivalents. The rocks appear like eruptives in the field. The clastic grains, when present and seen in thin sections of the foliated phases—gneisses—are evidently dynamic in origin; all are sharply angular, and none have the outline of water-worn grains. The structure of the gneisses is similar to that of like rocks occurring elsewhere, and shown to be metamorphosed eruptives. Therefore, since they conform with such regularity in mineral and chemical composition, and field evidences as well, to the massive granite type, there can be no reason for believing them to be anything but altered igneous rocks. No evidence of any kind is, at present, apparent to support the belief that the gneisses so far studied are water-deposited sediments, subsequently recrystallized by metamorphic processes.

As to the origin of the massive granites and their equivalent, porphyritic phases, there can be no doubt.

STRUCTURAL FEATURES: The structural phases of the various granite types have already been noted. Joint planes are very common in many of the larger masses and are as a rule, only slightly developed in others; and they traverse the rock with great regularity. They may conform to several different directions but usually they have uniform directions over the entire region. The best developed ones have nearly due east-west and north-south courses, approximating in some quarries northwest-southeast directions. Considerable subsequent movement in the granite-masses is manifested in many of the larger quarries, in pronounced slicken-sided surfaces of the joint planes. The slickened surfaces are, as a rule, coated with a moderately thick veneering of perfectly smooth, somewhat yellowish-colored sericitic material, frequently more or less grooved and striated from the movement.

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* Read by title at the Albany, N. Y., meeting of the *Geological Soc. of Amer.*, and presented in abstracted form by DR. GEO. P. MERRILL.

A preliminary report on the granites and gneisses of Georgia, by T. L. WATSON, *Geol. Sur. of Ga.*, in press.

Two sets of intersecting material differing widely in texture and mineral composition, and in origin, are common to the granitic rocks. These are: (1) True granite dikes, which vary in width from a few inches to many feet, cutting the rocks in a nearly vertical position; are dark blue in color, and fine even-granular in texture; and are composed of the same minerals in the same proportions, and have the same chemical composition as the even-granular granites. [Plate XXIV.] Since this class of intersecting material is not found in the more massive adjacent granites it is regarded in the nature of apophyses from these massifs. (See page 214 for chemical analysis.) (2) True pegmatitic dikes and veins of variable dimensions are common to the three rock phases and are composed of coarsely crystallized feldspar and quartz, with varying small proportions of the two micas, biotite and muscovite. [Plate XXII.] These are described in some detail on page 215.

AGE RELATIONS OF THE GEORGIA GRANITIC ROCKS.

No sedimentary rocks whose age is definitely known occur in the Plateau-crystalline-complex to admit of the definite determination of the age of the granites. In the absence of such, we can only hope to arrive at their relative ages by careful study of the contacts and the relative amounts of dynamic metamorphism the rocks have suffered. A careful field examination of the granitic rocks in the Plateau region of the state, shows considerable contrast in the amount of foliation or banding secondarily induced by pressure. All thin sections of the rocks studied showed some evidence of dynamo-metamorphism. This evidence is detailed above. The strongly banded gneisses differ from the massive phases of the rocks, simply in the pronounced schistose structure. In some areas of the massive granites an imperfect partial gneissoid structure is visible, which becomes rather noticeable in the Stone mountain area.

While no case has been observed in the field, where the highly contorted gneissoid phase was definitely traced into the massive type, owing perhaps, if they exist, to lack of exposures there are a few areas where conditions very strongly point to such gradation. Hayes[*] has described an extensive porphyritic granite area near the Cartersville fault in Bartow county, Georgia, in which the gradation from partially massive to a highly schistose granite is plainly visible. The stratigraphic relations of this igneous mass, to the surrounding sedimentaries of known age, cannot be mistaken, and Hayes has shown the intrusive granite, subsequently rendered highly schistose from intense pressure metamorphism, to be pre-Cambrian—Archæan—in age.

There appears to be, however, in most cases a sharp line of demarkation between the massive and slightly gneissoid granites, and the extreme foliated gneisses. In many areas where the schistose and massive granites occur, a part of the gneisses are cut by true granite dikes having the same mineral and chemical composition, as the massive granites, which they resemble in every respect. As elsewhere stated, the dikes are regarded as probable apophyses from the massive type of rocks. If then schistose structure secondarily induced or degree of metamorphism be taken as an index to age relationship, in the case of the Georgia granitic rocks, and accepting the evidence so strongly pointing to igneous origin for the highly banded gneisses, at least two different periods of intrusion of closely similar acid material are represented. The query naturally follows then whether all of these rocks have originated from the same parent magma?[†] Chemical and mineralogical composition more than suggest such condition.

A very close relationship in mineral and chemical composition is observed in the Georgia granites to similar rocks existing to the north in the Atlantic Coast region. Kemp,[‡] after a careful study of our present knowledge of the Atlantic Coast granites, has emphasized the great predominance of mica-granites, especially the biotitic types over others; and, with other investigators[§] has remarked their definitely known intruded character at different geological periods. Keyes[¶] remarks in his studies of a part of the Maryland granites: "Certain it is that the acid eruptives [granites] were among the last igneous intrusions to disturb the rocks of the eastern Piedmont Plateau." The same author states in a preceding sentence, that the granite may have been intruded as late "as the last great disturbance of the region preceding the Appalachian uplift."

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[*] Hayes, C. W., *Trans. Amer. Inst. Min. Engrs.*, Washington meeting, February, 1900.

[†] Kemp, J. F., *Bulletin Geol. Soc. America*, 1899, vol. x, p. 382.

[‡] Ibid, pp. 378-382.

[§] Williams, G. H., *15th Ann'l Rept., U. S. G. S.*, 1893-94, pp. 666-670. Dr. Williams reviews the distribution and relative ages of igneous granites in the Appalachian Crystalline belt and, gives numerous bibliographic references thereto.

[¶] Keyes, C. R., *15th Ann'l Rept., U. S. G. S.*, 1893-94, p. 733.

After a study of the Newark rocks of the "Richmond basin" in Virginia, Shaler and Woodworth,[*] in commenting on the age of the underlying rocks or "fundamental plexus", including granites and gneisses, say, "they probably date to Laurentian or Huronian time." (p. 418). And again on page 421 of the same report, the authors say, "The age of these rocks [granites and gneisses] is not locally determinable." The granites and gneisses of this area were grouped by Rogers[†] as Archæan.

Field and laboratory study of the granitic masses in the Georgia area certainly indicate, that they were not all contemporaneous in origin. Some of them are pre-Cambrian, while others may possibly be later in age. The youngest acid intrusives could not have been later however, *if as late,* which appears improbable from the existing facts and conditions, as the last great Appalachian disturbance or uplift.

Whatever age or ages be assigned the granites of this region, it is certain that the most massive types of the rocks exhibit strong proofs of mechanical strain, which indicates that since the intrusion of the last granites the region has suffered profound metamorphism.

METAMORPHIC FORMATIONS OF NORTHWESTERN CALIFORNIA.

By OSCAR H. HERSHEY, Berkeley, Cal.

INTRODUCTION.

That portion of the Klamath mountains lying west of Shasta county, California, is not quite a terra incognita to geologists, as it was visited by one of Whitney's exploring expeditions[‡] and has since been partially studied by Diller,[§] Fairbanks,[||] Anderson and the writer; but all that has been written about it was of a rather desultory character, hardly calculated to give one a comprehensive and correct knowledge of its geology. The present writer has been engaged in prospecting for the precious metals in the Klamath region for nearly two years, during which many sections of the territory have been traversed and although there was not carried on a systematic study of any particular geological problems, it has resulted, it is believed, in the accumulation of sufficient knowledge of the structural relations of the formations of that region to make possible a classification of the metamorphic rocks.

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[*] *19th Annual Report, U. S. Geol. Survey,* 1897-98 (1899) Pt. ii, pp. 385-515.
[†] *Geology of the Virginias,* 1884.
[‡] *Geological Survey of California,* vol. i.
[§] *Fourteenth Annual Report, U. S. Geol. Sur.* pp. 403-443.
[||] *Bulletin of the Geological Society of America,* vol. vi, pp. 71-101.

DESCRIPTION OF FORMATIONS.

The pre-Cretaceous rocks of the entire Klamath mountain region (aside from the eruptives occurring in batholiths and dikes and unquestionably of an intrusive character) may be classified into seven great formations as in the following table which represents their structural positions although not necessarily their age relations:

1.	The Upper Slates	or Bragdon formation.
2.	The Greenstone	or Clear Creek formation.
3.	The Lower Slate Series	
4.	The Hornblende Schist	or Salmon formation.
5.	The Mica Schist	or Abrams formation.
6.	The Serpentine	or Trinity formation.
7.	The Gabbro	or Tamarack formation.

The structural relations and age of the serpentine constitute the great problem in the geology of the Klamath region. In the Coast range region a petrographically similar serpentine is an altered peridotyte, unquestionably intrusive in the Franciscan series, of an age at least not earlier than the Jurassic; but in the Klamath region I cannot find the same evidences of the serpentine being intrusive in the metamorphic sedimentaries. The subject is a complex one, and requires further field work for its solution; hence, in this paper I shall confine my attention to the schists, slates and associated formations.

The Abrams mica schist.—Large bodies of schists of a prominently micaceous character are not of common occurrence in the rocks of the Klamath region except as constituting a single well-defined formation, for which from its relations to neighboring terranes being best worked out in the upper

Coffee Creek region, I propose the name of the Abrams post-office of that section. It is composed of thin folia of muscovite of dull colors, such as gray, light brown, yellow and dull red, separated by irregular layers of white quartz, representing the original laminæ. Throughout it is very highly siliceous and doubtlessly portions of it would by some be called micaceous quartz schist. In certain belts the silica predominates to such an extent as to cause it to outcrop like great veins of very glassy, white and dark blue quartz. The relatively great amount of this primary quartz is particularly characteristic of this formation. There are, also, in places thin folia of hard blue crystalline limestone, sometimes thickening and clearing to a beautiful white marble. The foliation of the formation is parallel to the top and bottom and in general to the original lines of stratification.

This particular schist formation occurs in a long narrow belt bounding the great serpentine area of northeastern Trinity county on the west. Beginning somewhere in Siskiyon county, west of Callahan, it runs continuously in a southerly direction across the valley of Coffee creek, the head of the south fork of Salmon river, and thence through the mountains just a little west of Weaverville. From here its course is southeasterly in conformity with the strike of all formations in southern and western Trinity county. The cañon of Weaver creek is cut principally into it and it is finely exposed along Trinity river near Douglas City. From here southward it widens out into a belt several miles in width and constitutes the mass of Bully Choop mountain, on the southern slope of which it sinks beneath the Cretaceous formations of the Sacramento valley.

In the southern portion of this schist belt it appears to be folded into at least two main anticlines along the axes of which serpentine outcrops in the form of narrow belts constituting the so-called dikes. I wish particularly to call attention to the fact that serpentine is commonly associated with this mica schist formation. The normal succession of the strata in the direction of the dip is invariably serpentine, mica schist and hornblende schist.

Another narrow north-south belt of mica schist crosses the south fork of Salmon River valley at the village of Cecilville.

Here it is bounded on the east by the great hornblende schist formation and along its west border occurs a narrow belt of serpentine.

The only remaining area of this formation known to me is developed in the vicinity of Yreka and Fort Jones in Siskiyou county where again it is associated with serpentine.

The thickness of the Abrams mica schist in the upper Coffee Creek section is estimated at about 1,000 feet, but it seems to thicken to the southward and at Bully Choop may be much greater.

This is undoubtedly a highly metamorphosed sedimentary. Originally it was a series of argillaceous sandstone beds in large part finely laminated. The action of the metamorphism has been to convert the nearly purely siliceous laminae into quartzyte layers, while folia of mica were developed in the shaly partings between the layers. In portions of the formation shearing such as usually produces schistosity has been nearly absent and the structure is rather that of a shale than a true schist. Yet this thermometamorphic action has been so intense that the original detrital granular nature of the material has been completely destroyed. Certain pure quartz sand layers have been converted into the apparent large quartz veins, which have a definite position in the series, are always parallel to the strike, and grade upward and downward into the distinctly laminated schist, yet rarely display the sub-granular texture of a typical quartzyte.

The Salmon hornblende schist. Whenever the boundary between the mica and hornblende schist has been examined by me, as in the south fork of Salmon River country and the Hay Fork section south of Trinity river, the former was found to grade into the latter through a thin series of graphite schist and actinolite schist. The black graphitic schist is particularly characteristic of this horizon and occurs nowhere else in the series. It was originally a highly carbonaceous layer in the succession of sandstones and shales and probably deposited under much the same conditions as veins of coal in the carboniferous rocks. The actinolite schist, so far as my observation goes, is also confined to this horizon. Usually it is of fine texture, light green in color and has a peculiar bladed structure, but locally there is developed a coarse-textured type yielding ne specimens of crystalline aggregates of actinolite. The raphite and actinolite schists combined usually have a thick-ess of no more than five to fifteen feet and in the presence of e broader belts of other schists on either side may escape de-ction in many sections unless especially searched for.

The hornblende schist is remarkable for its uniformity roughout a thickness of probably not less than 2,500 feet. It onsists of elongated or blade-shaped crystals of dark green d black hornblende, separated by irregular thin layers of hite quartz, with feldspar locally developed. It is moderately ne-grained and its general color is a dark green; it outcrops in gged peaks of black rocks. Certain layers are highly calcar-ous, abounding in curiously contorted folia of crystalline lime-one, even increasing to one- and two-foot layers of impure arble. Much of the formation has a schistosity developed by earing, but in places the original lamination can be distinctly iscerned and it is often highly contorted. There are other ortions in which quartz is nearly absent and the rock consists f massive aggregates of comparatively coarse hornblende crys-ls, producing a type resembling a truly igneous hornblendyte. ndeed, hand specimens of this formation have frequently been lentified as dioryte and even some who correctly discriminate as hornblende schist consider it an altered igneous rock. I ropose to show that it is a highly metamorphosed sedimentary.

The largest area of hornblende schist is traversed by the outh fork of Salmon river between its head and the vicinity f the village of Cecilville. It constitutes a broad, shallow, nclinal trough, trending north to south and probably ten iles in width. On each side the strata are upturned to the ex-nt of allowing the mica schist to come to the surface from un-er them. Both north and south from the river the synclinal further disturbed by the upthrust of the hornblende schist gainst huge batholiths of granite and quartz-mica-dioryte t the center of the structural basin thus formed, the forma-on has been less modified by metamorphic action than usually. he strata are but little tilted and the original bedding planes re quite distinct. Before its conversion into hornblende hist it passed through a stage of thin-bedded slate, the ructure lines of which yet remain. Interbedded with the hists there is a two to four-foot layer of dark gray, fine-grained compact quartzyte. In several places this shows shaly partings. Undoubtedly there is here evidence of the clastic character of the formation.

In the Hay Fork section of Trinity county, the Salmon hornblende schist is well developed as a belt several miles in width lying between the mica schist on the east and the black schistose slates of the Devono-Carboniferous on the west. In this area the schistosity is not so strongly developed and much of the formation is but little removed in alteration from a slate. In many places the bedding planes are distinct and indicate a formation originally not finely laminated nor yet very heavily bedded.

Another area of this formation occurs on the east side of the great serpentine area of the Sierra Costa mountains, on Rush creek several miles north of Weaverville.

We may now take a broader view of the schist series. The members are everywhere perfectly conformable to each other and evidently represent continuous sedimentation. At the base was an argillaceous sandstone with certain single heavy strata of nearly pure quartz sand. Following that was deposited a thin stratum of highly carbonaceous and siliceous shale. Another change in conditions brought in a more argillaceous and calcareous sediment and then followed a long period of remarkably uniform deposition of shale, sandy layers being few and fine in texture. All members of the series have been subjected to the same degree of metamorphism. Without shearing except locally, the first member was recrystallized into micaceous quartz schist, the second into graphite schist, the third into actinolite schist and the last seems to have passed through a slaty stage into hornblende schist.

The discussion of the age of this Klamath schist series will be reserved for the close of the paper.

The Lower Slate series.—This is made up of a succession of black slates, quartzytes and limestone. The slates nearly always have a schistose structure due to shearing. The quartzytes make up a large part of the series and are fine-grained and often regularly and thinly bedded. The granular structure and detrital origin are quite apparent to the unaided eye. The beds of quartzyte alternate rapidly with the schistose slates. The limestones occur in long narrow dike-like masses which are often repeated three or four times in parallel lines within several miles transverse to the strike of the slates, apparently as the result of folds or faults. Some of these "lime dikes" have a width of several hundred feet and stand out boldly above the surrounding slates. The limestone is usually massive and crystalline in character. Generally the metamorphism has proceeded to such an extent as to have completely destroyed the fossils, but near the Sacramento and McCloud rivers this is not the case, and there the limestones furnish the material for the determination of the age of this series.

The areas of the Lower Shale series are characterized:—

1. By the peculiar outcrop of the quartzyte; the surface of the hills abounds in fragments of cherty quartz either stained to light tints of red, yellow or brown or having a whitish, bleached appearance. It is difficult to convey an accurate impression of what is here meant, but it is a feature universally present in all the areas of this series no matter how widely separated or whether representing its upper or lower members. No other formation outcrops in quite the same way although internally it may resemble this.

2. By abundant dikes of greenstone intruded into the series and cutting across the stratification.

3. By the belts of limestone. Limestone and marble occur in the earlier schists but are insignificant in development in comparison with those of the Lower Slate series.

4. By a certain degree of dynamo-metamorphism which is comparatively uniform throughout the series and is of the nature of regional and not local or contact metamorphism.

The formation is commonly contorted, faulted and sheared throughout. Much of the argillaceous material has been converted into hornblende and micaceous minerals, but this is not macroscopically prominent. The sandstones have been partially recrystallized and thoroughly lithified. The limestone has usually been altered to a distinct crystalline aggregate presenting little evidence of its original condition. The general appearance of the series is one of practically the same age throughout, and as a whole much older than the Mesozoic slates, to be described later, and much newer than the schist series, discussed in preceding pages.

In Trinity county, the Lower Slate series is chiefly developed in a belt lying just west of the hornblende schist, trending from southeast to northwest from the vicinity of Harrison Gulch in Shasta county, across the Hay Fork country and the Lower Trinity basin. and crossing the divide into Siskiyou county in the New River mountains. It is traversed by the south fork of Salmon river below Cecilville, where much of the country over a width of ten or fifteen miles belongs to this series. The belt probably averages about five miles in width.

The next principal area is in the Scott Valley region, between Fort Jones and Callahan, and extending thence east to Shasta valley near Gazelle. The Sacramento cañon cuts a number of small areas of this formation between Castella and Delta, and it largely occupies the country east of the river to and beyond the McCloud river.

The age of the series is pretty definitely known through fossils occurring in it near the Sacramento and McCloud rivers and studied by Trask,* Walcott, Smith,† Diller, Schuchert,‡ Anderson and others. A small area near Kennett is considered Devonian in age, and in limestone near Gazelle has been found a fossil fauna indicating still lower Devonian. I understand, also, the Devonian fauna occurs in the series in the Scott Valley region. On the McCloud river a Lower Carboniferous fauna is found in the Baird shales and an Upper Carboniferous in the McCloud limestone. Prof. J. P. Smith has informed me that farther up the McCloud river there are fossils of a Permian facies. Hence, it appears, that the Lower Slate series ranges in age from the Lower Devonian to Permian, and as there is no known stratigraphic break in the series, sedimentation was probably continuous throughout Devonian and Carboniferous time. Metamorphism in the McCloud region has been somewhat less in intensity than in the southwestern Siskiyon and Trinity areas. It is to be noted, however, that the small Devonian area near Kennett more closely resembles the series in Trinity county than the Carboniferous area in the McCloud, and the more aged appearance of the western areas may be due not alone to their different situation in the range but also to their representing the older or Devonian portion of the series.

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* *Report on the Geology of the Coast Mountains*, 1855.

† "The Metamorphic Series of Shasta county, California," *Jour. of Geol.*, vol. ii, pp. 588-612.

‡ "Discovery of Devonian Rocks in California," *Am. Jour. Sci*, III Series, vol. xlvii, pp. 416-422.

This series of slates, quartzytes and limestones certainly represents in part the Calaveras formation of the Sierra Nevada region, but also seems to include strata of the same age as the Arlington and Robinson formations. The Devonian portion of the series is not well represented in the Sierra Nevada region, but strata of that age have been discriminated there. I should be inclined to extend the term Calaveras in its original significance to the Klamath region if it had not come to be restricted to a particular portion of the Devono-Carboniferous series. It is doubtful if we shall be able to separate the Devonian and Carboniferous components of the series in the southwestern Siskiyou and Trinity areas, and we may be obliged to adopt a collective name synonymous with that which I have used, the Lower Slate series.

The thickness of the series in any one section is not known to me. Usually the succession of strata is repeated several times in a single area by faulting and folding. It appears to be considerably thicker than the schist series and than the later Mesozoic slates, and an estimated average for the entire territory of 5,000 feet is probably sufficiently accurate for the present.

The Clear Creek greenstone.—Southeast of the high rugged peaks constituting the Sierra Costa range, there is a much lower mountain country constituting the basin of Trinity river between Trinity Center and Lewiston, the Trinity mountain and the ridges eastward to the Sacramento river. The geology of this extensive territory is comparatively simple and entirely unlike that of the country to the west. Aside from the intrusive granites and porphyries, the mountains are made up of two formations, the Clear creek greenstone and the Bragdon slates. The former is the foundation rock of the region and upon it the slates have been deposited.

In general, the slate formation remains practically in its original horizontal position except that it has been thrown into a broad, shallow syncline, with an axis a few miles east of the summit of the Trinity range; but, considered in detail, it is much disturbed by faults and folds of small dimensions so that locally it presents dips of high degree, in not a few cases vertical and even overturned. This folding somewhat obscures the fact that the greenstone is always under the slates and never intruded into them.

The whole black slate country between Trinity Center and Lewiston has been thrown into a series of about ten anticlinal folds, striking east to west through the Trinity mountain and across the courses of Trinity river and Clear creek. Near the center of the series the folds are closely oppressed and the slates along the sides vertical. Now, if we follow the contact between the greenstone and slates up the limb of the anticlinal we do not have to climb more than 500, or at most 1,000, feet above the Trinity river until we find the slates curving up over the greenstone, and the mountains above are entirely of slate. The maximum vertical range of the folding is probably 2,000 feet, and the more open folds may be included within 1,000 feet. Thus the greenstone rises into view in the axis of each anticline, and sinks beneath the valley under each syncline.

The greenstone formation is made up of a variety of deposits of a volcanic nature, but all having something in common so that it appears over wide areas as a massive, fine-grained dull green rock, outcropping in ragged cliffs and weathering down into a reddish clay soil.. Much of it is of a detrital character, chiefly diabasic tuffs and ashes, although in places it is brecciated and occasionally it has a conglomerate structure. This latter is peculiar. It consists of rounded pebbles of diabase cemented by similar material. Among the diabasic tuffs are undoubtedly sheets of lava, in places containing amygdaloids. The formation has been much altered and abounds in secondary minerals of which epidote is macroscopically the most prominent.

Running through the greenstone areas are long broad belts of a fine-grained white rock resembling certain quartzytes, but apparently a felsyte or a devitrified rhyolyte. Commonly associated with them are zones of impregnation of iron and copper pyrites, the sulphides sometimes concentrating into large solid bodies, such as the Iron mountain and Copper city deposits.

Along certain zones of shearing which trend usually east-west and have a width of ten to hundreds of feet, the diabase has been converted into a light-greenish schistose rock which appears to me to answer the description of certain phases of the amphibolyte schist of the Sierra Nevada region. Bands of impregnation of sulphides are also commonly associated with these shear zones.

Another modification of the diabase quite common along Trinity river is into a very hard, fine-grained, purplish flinty rock, perhaps due to silicification of the greenstone. In the same region occur dikes of quartz-porphyry which cut the greenstone but terminate abruptly at the base of the overlying slates. In fact, the whole greenstone formation appears to be a series of diabasic tuffs and lavas bound together by a variety of intrusive porphyries and diabase.

This greenstone in large part is beyond doubt extrusive in character; in other words, it is a formation of surface volcanic material. It has its counterpart in the Neocene tuffs and lavas spread widely over the older formations in the Cascade region. On the isthmus of Panama, I have studied a great Neocene volcanic formation of precisely the same character, except that the tuffs are mainly rhyolitic and the lavas basaltic. The internal structure of these formations is characteristically alike.

The origin of the material of the greenstone has not yet certainly been discovered. The Lower Slate series is particularly abundantly supplied with dikes of greenstone scarcely distinguishable from the main body of the diabase and in places these intrusive diabases seem to pass into the extrusive formation. In the Cinnabar synclinal between the gabbro ridges of northeastern Trinity county, great dikes of greenstone are intruded into the serpentine and form extensive bodies along the axis of the trough. The entire region from the Sacramento river southwestward to the Hay Fork country and northwestward to the lower Salmon river country appears to have been overspread by this greenstone, for wherever its proper horizon is exposed, viz., between the Lower Slate series and the Bragdon slates, heavy bodies of diabase occur as a stratigraphic unit and not as intrusions.

Tuffs imply volcanoes and not mere fissure eruption. The volcanoes of this period have disappeared, but I think they occurred along a belt lying just west of the Sacramento river and including the sites of, say, Kennett, Keswick, Shasta and Centerville. Here the formation is very thick and its fragmental character is most apparent. Toward the westward it appears to thin and become more uniformly a diabase similar to the dikes in older formations. Its thickness is unknown, but in Trinity valley it is at least 1,000 feet, as that thickness is exposed and the bottom not seen.

The Clear Creek greenstone was deposited on land. At the close of the epoch it suffered erosion and was levelled off either by the sea, during the progress of the submergence to which the slates are due, or by sub-aerial erosion, probably as the result of both. This interval of erosion does not appear to have been a long one.

The Bragdon slate.—This has its heaviest development in the Trinity mountain (the bulk of which it forms) between the high mountains east of Trinity Center and the vicinity of Lewiston. It is cut off on the west at the foot of the high Sierra Costa mountains by a sharp monocline or a fault. On the east it thins out because of erosion and has been completely removed from over the greenstone formation along a broad belt lying just west of the Sacramento river.

It is a series of alternating thin-bedded black slates and thick-bedded blue quartzytes. As doubts have been expressed that this formation is distinct from the Devono-Carboniferous I will lay special stress upon the points of difference. In the lower slates, the quartzytes are white and weather red, yellow, brown or a bleached white; in the Bragdon slates, the quartzytes are blue and weather gray. The former formation is schistose throughout the argillaceous portion because of regional shearing; the Bragdon slates have only been sheared along certain zones, and most of the formation is merely a well lithified or silicified shale and sandstone, without shearing. The Lower Slate areas have limestone; the Bragdon slate areas none. The former series abounds in intrusive diabase; the latter has no dikes of this eruptive and all the diabase in its vicinity is under it. Conglomerates are rare in the Devono-Carboniferous; in the Bragdon slates thin sheets of well-lithified, moderately fine conglomerate are rather common, particularly in Hay gulch, three miles north of Bragdon, and near French gulch. The pebbles are of blue, black, red, yellow, brown and white quartz and appear to have been formed principally from the quartzytes, cherts and phthanytes of the Devono-Carboniferous.

Along the Sacramento river, near Elmore and thence eastward toward the McCloud river, there is a deposit of the Bragdon slate. It contains conglomerates which on outcrop have a singular-vesicular character, like an amygdaloid. Now there are Devonian and Carboniferous limestones pretty strongly developed in that vicinity and I explain the rounded cavities in the conglomerate by supposing that they represent pebbles of limestone which have been dissolved out in the process of weathering.

The conglomerates are most abundant toward the northeast, and the whole formation seems to thin toward the southwest, implying that the shore-line and source of the sediments were somewhere on the northeast. In the Hay Fork country, lying west of the Devono-Carboniferous, there is a narrow belt of this formation. Here also it is closely associated with greenstone, as in Trinity mountain. The two are folded into each other and are separated by a sharp even line, with the greenstone always stratigraphically under. Both greenstone and slates are thinner than in the Trinity mountain area and the latter average finer sediments.

The Bragdon slates were probably developed over the greater portion of the Klamath region, but through the vicissitudes of elevation, folding and erosion, have been mostly destroyed. This is the latest of the formations included in the "Auriferous Slate series" of northwestern California and probably the upper limit of the original deposit nowhere remains. There are yet over 2,000 feet in thickness of it in the Trinity mountain country.

The age of the Bragdon slates is as yet somewhat uncertain, as the formation has nowhere yielded any determinable fossils. Along the road between French gulch and Trinity Center, near Whitney's ranch, there are traces of organic remains, apparently impressions of plants. However, no paleontological evidence is available and I can only indicate what correlations are probable from the standpoint of lithology, stratigraphy and structure.

In the Pitt River region, Prof. J. P. Smith has discriminated* a thick series of Mesozoic sediments included in part in his Pitt formation and the Cedar and Bend formations, the latter of Jurassic age. There appears to have been essentially continuous deposition from the Carboniferous through the Triassic into the Jurassic. My acquaintance with that region is slight, but when I visited it I could not so clearly separate the Carboniferous and Mesozoic slates as in Trinity county. My impression is that the latter formations are entirely unrepresented in Trinity county, their place being taken by a marked interval of erosion. In the Pitt river valley I found the slates grading into the greenstone by interstratification, while in Trinity county they are distinct and a short interval of erosion belongs between them. My studies lead me to think that throughout the Klamath region west of the Sacramento river, sedimentation ceased at the close of the Paleozoic era and the Devono-Carboniferous series was elevated into dry land, somewhat folded and metamorphosed and then greatly eroded, while sedimentation continued through the Triassic and Jurassic periods in the region of the McCloud and Pitt rivers, and thence northeastward through an undetermined area. Sedimentation in the country west of the Sacramento river was only resumed well on in the Mesozoic era, after the Clear Creek volcanic period, and hence the greenstone and Bragdon slates (which rightfully belong together as a series) came to rest unconformably upon the Devono-Carboniferous.

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* *Jour. of Geol.*, vol. ii, pp. 558-612.

Now, there is a remarkable resemblance in the lithology and structure of the Clear Creek greenstone and the main diabase and porphyryte formation of the Sierra Nevada region. Both seem to represent a time when diabasic tuffs and lavas spread over wide areas much as the Neocene volcanoes cover the older formations in the Cascade region. In the Sierra Nevada region also this extrusive series of eruptives is intimately associated with a black slate formation—the Mariposa slates of late Jurassic age. Not only are the Bragdon slates lithologically similar to the Mariposa slates, but the general make-up of the two series is identical. This parallelism of conditions on opposite sides of the comparatively narrow Sacramento valley is too remarkable to be ignored. It seems to warrant the correlation in a general way of the two series. As the Mariposa slates with their associated diabase and porphyryte are considered late Jurassic in age, I shall provisionally class the Clear Creek greenstone and the Bragdon slate as also Jurassic.

DISCUSSION OF THE AGE OF THE KLAMATH SCHIST SERIES.

The common association of serpentine with the Abrams formation suggests that the peridotyte was intruded into the slates and that the schists represent contact zones of metamorphism about it, and are merely altered portions of the Devono-Carboniferous series or the Bragdon slates. To this hypothesis there are two fatal objections.

1. The original or unaltered sedimentary formations of the schist series, the Devono-Carboniferous series and the Bragdon slate series were of a similar character petrographically (and might be expected to yield like products under like conditions of metamorphism) *but the sequence of the strata was different.* No amount of metamorphism could have converted the Bragdon slates or any portion of the known Devono-Carboniferous into a series as the mica, graphite and hornblende schists. That layer of graphitic schist is extremely important in this connection. By means of it and the nearly purely siliceous layers outcropping as apparent large glassy quartz veins, we are able to determine that the mica schist everywhere in the Klamath region represents the same portion of the original sedimentary series, and the hornblende schist always a certain higher portion while the recognized Devono-Carboniferous nowhere contains representatives of this portion of the original sediments and the Bragdon series is so very different as to be quite out of the question.

2. Along several lines in the Klamath region the Devono-Carboniferous and the schist series are in contact and "dikes" or narrow belts of serpentine appear along these lines. On Hay Fork mountain in southern Trinity county, a narrow belt of the serpentine is bounded on the west as usual by mica schist, followed by the graphite and hornblende schists. On the east it is bounded by a belt of the characteristic schistose slate (cut by greenstone dikes) of the Devono-Carboniferous. Now, if the mica schist is an altered portion of the Devono-Carboniferous and due to the intrusion of peridotyte, why was the metamorphic action so very much more intense on one side of the dike than on the other? These conditions are exactly repeated along the boundary between the undoubted Devono-Carboniferous and the schist series in the vicinity of Cecilville and the King Solomon mine in southwestern Siskiyou county, except

that here the schists are on the east and the slates, quartzytes and limestone on the west of the serpentine.

The serpentine is mainly confined to low levels, and higher the slates and quartzytes rest directly on the mica schist and the contact appears to be unconformable. It seems that the schist series was tilted to the eastward at a considerable angle and the Devono-Carboniferous laid down arcoss the beveled edges of its strata. Similar evidence of non-conformity was obtained on Hay Fork mountain. If the serpentine is older than the schists there will not be any difficulty in demonstrating an unconformity indicating an immense erosion of the schists previous to the deposition of the Devono-Carboniferous sediments, but if the peridotyte was intruded into schists and slates, the unconformity rests upon less definite evidence and more work will be required to establish the fact beyond the possibility of doubt. However, it is a fact that the typical Devono-Carboniferous comes close up to the typical schists and they are separated by a sharp line, not the least evidence of one grading into the other having ever been found.

Throughout the Devono-Carboniferous areas, narrow belts or so-called "dikes" of serpentine are rather common. They usually outcrop at lower levels, the schistose slates and quartzytes apparently curving up over them as does the Bragdon slate over the Clear Creek greenstone in the folds of Trinity valley. One such strip of serpentine forming the axis of a narrow fold occurs in Bridge gulch in the Hay Fork section. The typical schistose slate and quartzyte of the Devono-Carboniferous overlie it and may be traced to the very contact practically unchanged. In the Scott valley region south of Fort Jones in Siskiyon county, a sheet of serpentine appears to underlie the Devono-Carboniferous over at least several square miles. In no instance have I observed the development in these Devono-Carboniferous areas of a mica schist or a graphite schist or a hornblende schist along the contact, such as constitute the Abrams and Salmon formations. It would be too remarkable a case of selection to suppose that the peridotyte converted thousands of feet of strata into mica and hornblende schists in one area, and that in an immediately adjoining area, equally as large masses of peridotyte failed to develop in the same strata even a narrow contact zone of similar schist. The inference is unavoidable that the schists are a distinct series, as a whole much more highly metamorphosed than the Devono-Carboniferous, and that at least to the extent that their alteration exceeds that of the other series, the metamorphism is not due to the intrusion of peridotyte.

In the Coast Range region the serpentine areas are commonly bounded by narrow zones of contact metamorphism, the product of which is in places a schist as thoroughly crystallized as any part of these Klamath schists. These metamorphic zones are nowhere of great extent and cannot be used as an argument in support of the hypothesis that to the intrusion of the peridotyte is due the high degree of metamorphism of the Abrams and Salmon formations which are developed over hundreds of square miles without an outcrop of serpentine. Moreover, serpentine areas five to ten miles in width adjoin the Clear Creek greenstone and the Bragdon slates, as in the Hay Fork section of Trinity county, without the presence of a prominent schist belt if, indeed, there is any contact thermo-metamorphism apparent at all.

It has been suggested that the schists represent contact metamorphic zones due to the intrusion of a granitic batholith. Where these batholiths rise through the hornblende schist as near the head of the south fork of Salmon river, there is often a narrow belt of schist next to the granite. However, this is always merely a portion of the Abrams formation normally underlying the hornblende schist and thrust up along the granite contact *as the presence of the graphitic layer proves.* Large batholiths of granite, quartz-mica-dioryte and intermediate types occur in the areas of the Devono-Carboniferous and of the Bragdon slates and in no case are they surrounded by schist zones such as the Abrams and Salmon formations. In fact, the only sort of contact metamorphism that I have observed in the Klamath region about the granitic batholiths is that the schists and slates near the border have often been contorted by the pressure of the intruded magma, and impregnated with sulphide of iron and in general their metamorphism somewhat intensified but not materially changed in character.

Another suggestion is that the metamorphism of the rocks of the Klamath region is due to the action of a great magma of fluid granitic material underlying the whole territory and deeply buried beneath the present surface level but exerting its influence high in the overlying strata to a degree which the comparatively small batholithic arms could not. This would imply that in any given area, there was a maximum of intensity of alteration in the deepest portion of the strata near the granitic mass and the degree of metamorphism decreased upward toward the surface. The oldest sediments would naturally be buried deepest and be the most altered. Afterwards elevation and folding would bring the deeper strata to the surface and belts of schists would come to outcrop parallel with the belts of but slightly altered slates. As applied to the Klamath region I have the following objection to make to this hypothesis:

No fluid granite magma existed under the Klamath region until after the Jurassic period of eruption of greenstone. During the deposition of the Bragdon slates or immediately after, such a granitic magma may have formed under the region, and when, just at the close of the Jurassic period, the entire territory was uplifted, folded, faulted and extensively fractured, the strata subsided on this fluid magma and the batholiths and acid dikes were formed. Now, did the metamorphism of the schists and slates date entirely from this period, there should be a gradual transition in the degree of alteration from the oldest and lowest to the newest, which certainly is not the case.

I want to particularly emphasize the facts that the schist series is about equally metamorphosed from bottom to top and throughout its extent over hundreds of square miles, that then occurs a break, so to say, and the Devono-Carboniferous series although showing some variation, as a whole is altered to practically the same degree, but *much* less than the schists although the two are in contact in places, while then occurs another "break" and the Jurassic series although showing little variation in metamorphism throughout its extent either vertically or horizontally, as a whole is much less altered than the Devono-Carboniferous. Taken in connection with the evidence of unconformity between the three series the only reasonable explanation is this:

After the sediments of the schist series were deposited, they uplifted, tilted, *to a certain degree metamorphosed,* and then eroded. This land was depressed beneath the sea and the Devono-Carboniferous sediments deposited. At the close of the

Paleozoic era, there occurred another uplift and tilting of the strata. The Devono-Carboniferous formations *were metamorphosed to nearly their present degree,* while in the earlier series which had previously been converted into schists, *there was an intensifying of the metamorphism.* In the Jurassic there came another submergence with the deposition of the Bragdon slates, followed by the uplift, folding, faulting and fracturing of the strata to which the present Klamath mountains structurally are due. During this orogenic disturbance, the Clear Creek greenstone and Bragdon slates were well lithified, partially silicified, and a schistose structure developed along certain limited shear zones; in other words, the Jurassic series *was slightly metamorphosed.* At the same time *there was another intensification of the alteration* of the schists and Devono-Carboniferous series. This theory so well explains the facts observed in the mountains that it is hardly necessary to call into play possibilities which are not strong probabilities.

It is true that there are throughout the Klamath region certain narrow zones of metamorphism due to the intrusion of various acidic and basic dikes, and they have produced even in the Jurassic slates, schists of somewhat similar mineralogical composition to the Klamath series, but the local character of the former is always manifest and there is no reason for confusion. In this paper I am considering only the alteration that is regional in character, affecting entire formations over many hundred square miles. In the case of the Klamath schists this was probably due to their having been deeply buried under other sediments and brought under the influence of the internal heat of the earth. The regional alteration of the Devono-Carboniferous and Jurassic series is mainly of a dynamical character. Upon this is locally superimposed the thermo-metamorphism of the central zones.

We are now ready to consider the question of the age of the schists. They contain no fossils and manifestly our conclusion must be provisional and subject to modification at any time.

I feel safe in asserting that they are considerably older than the Devono-Carboniferous series. They seem to be separated from the latter by a non-conformity of no mean value and certainly by a great difference in degree of metamorphism. The relation in point of metamorphism between the Jurassic, Devono-Carboniferous and schist series of the Klamath region is similar to that between the Carboniferous, Cambrian and Archæan of the Appalachian region. Upon a superficial survey the Abrams mica schist might be classed as Archæan in age. However, I do not think it is that old, for the following reasons: The Archæan complexes of the eastern states are almost invariably highly contorted and their original clastic nature totally destroyed, if, indeed, any parts of them are metamorphosed sedimentaries. As we approach the Pacific coast, the supposed Archæan terranes are less contorted, but the original planes of deposition are usually not apparent. The series contains granites, gneisses and schists, but never, so far as I know, such an assemblage of formations as the mica, graphite and hornblende schists of the Klamath region, and so perfectly preserving in considerable areas their original stratified structure.

The general appearance of the series is similar to that of the Algonkian formations in the Appalachians, lake Superior region and the Black Hills of South Dakota. These Algonkian terranes frequently are but little contorted, lie at comparatively low angles, display evidence of their clastic nature and original stratification, and yet are highly crystalline in character. The same is true of the Klamath schist series.

Opposed to the idea of a Cambro-Silurian age for the Klamath schists is the presence in different parts of California of known Silurian and Cambrian strata much less metamorphic in character. About the northern end of the Sierra Nevada mountains Diller has found strata whose fossils indicate a Silurian age.* From the description, these do not appear to be greatly more altered than the Carboniferous of the same region or the Devono-Carboniferous of the Klamath region. In Inyo county, there have been found Lower Cambrian strata, also not more metamorphic in character than the Devono-Carboniferous of the northern part of the state.†

Yet, in other parts of the Sierra Nevada region there are schists very similar in character to those discussed in this paper, notably in the Big Trees area.‡ It is usually implied that these schists are only more altered portions of the Carboniferous or Jurassic slates, and this is probably true of them in large part. Some of them are referred to as possible representatives of pre-Cambrian formations. As the Klamath region is merely a sort of outlier of the Sierra Nevada, so far as its stratigraphical and earlier dynamical geology is concerned, it is probable that in time a part of the Sierra Nevada schists will be definitely separated from the Carboniferous and Jurassic series and correlated with the Klamath schists.

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* Descriptive text of the Lassen peak folio, *U. S. Geol. Atlas.*

† *Am. Jour. Sci.*, vol. xlix, 2395, p. 141.

‡ *Seventeenth Annual Report*, *U. S. Geol. Sur.*, p. 536. *Am. Geol.* vol. xiii, 1894, p. 229.

On the whole, it seems impracticable to fix upon any particular part of the time between the Archæan and the the Devonian as the period of deposition of the Klamath schists, but I believe the evidence favors the earlier or Algonkian portion rather than the Cambrian or Silurian, although I should not like to be placed on record as correlating these schists with the Algonkian in any other than an extremely problematical way.

Berkeley, Cal., Jan. 3, 1901.

ON THE HELDERBERGIAN FOSSILS NEAR MONTREAL, CANADA.*

By Charles Schuchert, Washington.

St. Helen's Island in the St. Lawrence river, opposite Montreal, and now one of the public parks and fortifications of that city, furnishes an interesting bit of geology. At the upper extremity of the island, close to the ferry landing, is seen the Utica shale cut by dikes of a highly altered basic rock and an intrusive sheet of dioryte lamphrophyr (=camptonyte), and overlain by agglomerate which covers almost the entire island. Around the island to the southeast are occasionally found small blocks of limestone containing Trentonian fossils, such as *Plectambonites sericeus, Strophomena incurvata*, and monticuliporoid Bryozoa. Towards the southeastern end of the island, along the water front, occurs the Helderbergian exposure. Logan† describes the latter as follows: "There occur two masses of dark gray fossiliferous limestone, weathering to a light gray; which are not magnesian. These are included in a length of about forty yards, and are limited on the east side by the water of the river; they have a breadth of scarcely more than ten feet, and appear to run under the dolomitic conglomerate [agglomerate] on the west side. They present, in section, the appearance of two small arches of about four feet in hight, separated from one another by a few feet of the [agglomerate], and sinking under the same rock on the north and south. * * * The dolomite [of the agglomerate] and the limestone seem to pass into one another for a few inches, and show no tendency to separate at the junction. * * *

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* Published by permission of the Secretary of the Smithsonian Institution.

† *Geology of Canada*, 1863, pp. 356-358.

"As none of this limestone comes from beneath the [agglomerate], where this reposes upon the Utica fromation, it is supposed to belong to a small disturbed lenticular portion, lying in or under the [agglomerate]. Smaller patches of the same limestone, a few feet in diameter, are seen in the forty yards north of the two chief masses; and the whole may be connected beneath. There are other masses of similar limestone, only a few inches in diameter, which are completely enveloped in the conglomerate."

The writer made two visits to this locality in August, 1900. He found the Helderbergian limestone considerably broken and disturbed, with all the crevices filled up by the dolomitic paste of the agglomerate which covers the island. The amount of this limestone exposed is too great to warrant any assumption other than that it represents an outlier *in situ* above the Utica, having been subjected to seismic action shortly before the deposition of the agglomerate. The stratification of the limestone, as seen by the lines of fossils, is too irregular to make out the general lay of the mass.

In the grassy slope but a few feet away from the Helderbergian, there is a large block of a slightly granular siliceous limestone involved in, and forming a part of, the agglomerate. A number of fossils have been collected from this block and mixed up with some from the Helderbergian. These specimens, however, by their color and preservation, can be readily distinguished from those of the Helderbergian limestone, and have nothing in common with the latter. They will be mentioned again later on.

THE HELDERBERGIAN FAUNA.

In the Geology of Canada cited, Logan lists 9 species determined by Billings. It is not necessary to reproduce this list, as *Strophonella punctulifera* and *Rhipidomella oblata* correctly indicate "the existence of the Lower Helderbergian group in two or three small outliers in the great western basin near to Montreal."

Subsequently, J. T. Donald[*] published a list of 35 species, among which are *Orthis hipparionyx, O. oblata, O. tubulostriata, Strophomena punctulifera, S. profunda, Spirifer concinnus, S. cyclopterus, Stricklandinia gaspensis, Pentamerus verneuili, P. galeatus,* and *P. pseudogaleatus.* Here are forms characterizing the Niagaran, Helderbergian, and Oriskanian formations, an assemblage never met with in America.

In 1890, Mr. William Deeks[†] restudied these fossils and extended the list to 44 species. Here again appears the same remarkable assemblage first noted by Donald. In 1896, the fossils of Donald and Deeks, now in the Peter Redpath Museum, were re-examined by Dr. Ami, who published a list of 45 species.[‡] This list differs greatly from those previously given, and is far more satisfactory, as the species included are apparently of the Helderbergian or Oriskanian age, excepting a Spirifer "very much like *S. pennatus* (=*S. mucronatus*)." In the writer's resumé of the American Lower Devonic faunas[§], it is stated that one specimen of *Spirifer concinnus,* as identified by Donald, "is more like *S. cumberlandiae,* but the bilobed fold of the dorsal shell is a character which associates his species with *S. mucronatus* Conrad, of the Hamilton." Assuming at that time that all the St. Helen's Island fossils are from the "conglomerate," and as *Spirifer mucronatus* and "Spirifer apparently near *S. granulosus* Conrad" indicate a Middle Devonic formation, that age was accepted for the "conglomerate" and Dr. Whiteaves was so informed. The latter, in his presidential address before section E of the American Association for the Advancement of Science[‖], stated, with the permission of the present writer, that the St. Helen's Island fossils "are probably the equivalent of part of the Hamilton formation of Ontario and New York, and not of the Lower Helderberg." It is true that Dr. Ami was the first to notice the Spirifer "very much like *S. pennatus*" but he made no correlation from it. Finally, in the paper cited above, the writer stated —"Under these circumstances, judgment is deferred as to the age of the conglomerate on Saint Helen's Island."

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[*] *Canadian Naturalist*, n. ser., ix, 1881, pp. 302-304.
[†] *Canadian Record of Science*, iv, 1890, pp. 104-109.
[‡] *Ann. Rept. Geol. Surv. Canada*, n. ser. vii, 1896, pp. 155J-156J.
[§] *Bull. Geol. Soc. America*, 1900, p. 332.
[‖] *The Devonian System in Canada*, 1896, p. 16.

After an examination of the fossils in the Peter Redpath Museum and of their mode of occurrence on the island, the evidence seemed conclusive that true Helderbergian rocks *in situ* do occur in this locality, and that some of the identifications of Donald and Deeks need rectification. Mr. E. Ardley of the Redpath Museum also showed the present writer a small slab broken from the siliceous limestone block in the agglomerate, which contains several well-preserved, long-winged Spirifers, like *S. pennatus*. Other specimens of a Spirifer from the same rock were also shown, all of which proved that these fossils have nothing in common with the adjacent Helderbergian fauna, but belong to one of Middle Devonic age. The collections in the U. S. National Museum are too meager for detailed comparison, and in this article the writer cannot do more than correct some of the identifications of Donald and Deeks, while pointing out the probable correlations of the Saint Helen's Island fossil faunas with those of New York.

"*Heliolites*," Deeks.

This seems to be based on a *Striatopora*. There is no *Heliolites* in the locality.

"*Orthis hipparionyx**," Donald and Deeks.

This identification is an error. The specimen pertains to the same form as the "Spirifer allied to *S. arenosus*." Both these identifications are based on a Spirifer apparently near *S. granulosus* Conrad, and *S. eurytienes* Owen, of the Middle Devonic. The specimens are from the block in the agglomerate, and have no connection with Helderbergian fossils.

Rhipidomella cfr. musculosa Hall?

In the U. S. National Museum collection, there is a fragment of a large *Orthis*, or rather, *Rhipidomella*, from the Helderbergian, which may be this species.

Rhipidomella cfr. *musculosa* Hall?

These specimens are usually smaller than those from New York, otherwise they are alike for both regions.

"*Strophomena profunda* Donald, *Strophodonta profunda*" Deeks.

This Niagaran species was not present in the Redpath collection last summer, nor is it listed by Dr. Ami. *Strophomena profunda* must therefore be removed from the Saint Helen's Island Helderbergian.

Stropheodonta varistriata var. *arata* Hall.

The National Museum specimens of this form are poor, but seem to agree with the New Scotland variety of the species, as found at Becraft Mt., near Hudson, New York.

Strophonella punctulifera (Conrad).

The specimens thus labeled in the Redpath Museum belong to an *Orthis* near *oblata* and a *Stropheodonta*, probabaly *S. varistriata* var. *arata*. However, the species doubtless occurs on the island, since Dr. Ami has it in his list.

Spirifer concinnus Hall.

This is one of the common species and appears in its typical form.

Spirifer murchisoni Castelnau, early variety.

This is the commonest fossil of St. Helen's Island, and in the Montreal collections is usually found labeled as *S. cyclopterus*. It has, however, the general expression of a somewhat under-sized *S. murchisoni* from Cumberland, Maryland. It differs from the former species in being, as a rule, more alate, with fewer and more prominent plications. Tracing these early departures from *S. cyclopterus*, the progression terminates in the Upper Oriskanian in the typical *S. murchisoni* of large size, extreme inflation, angulation of the plications, fold, and sinus, and great lingulate extension of the ventral shell.

"*Spirifer allied to arenosus*" Donald, Deeks, and Amo.

This is apparently the earliest form of the *S. arenosus* type. However, it is not that species, since when small it is much like *S. concinnus*, but towards maturity the fold and sinus become plicated. Hall and Clarke figure a similar specimen as *S. concinnus* (Pal. N. Y., VIII, Pt. II, pl. 30, fig. 1). In *S. arenosus* of the Oriskanian, the horizon for this species, the plication of the fold and sinus is not a recently acquired character for it appears in the shell when quite small.

"*Stricklandinia gaspensis*" Donald and Deeks.

The specimen in the Redpath Museum has nothing in common with this species. It is one of those large rhynchonelloids now referred to *Camarothoechia (Plethorhyncha)*, nearest to *C. (P.) pleiopleura* Hall. This is one of the interesting representatives of the Saint Helen's Island Helderbergian fauna in that it shows transition into Oriskanian forms. Dr. Ami has likewise noted this species.

"Pentamerus verneuili" Donald and Deeks.

If based on the specimen thus labeled in the Redpath Museum, this identification is an error for *Spirifer concinnus.*

Gypidula pseudogaleata (Hall) ?

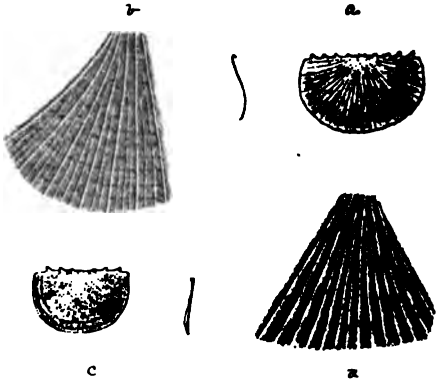
The material in the National Museum representing this species is very imperfect, but it shows that the form is a *Gypidula* without plications. Since *G. pseudogaleata* is the only Helderbergian species of this type, the St. Helen's Island specimens are provisionally identified with Hall's species so characteristic of the Becraft limestone.

Rensselaeria aequiradiata Hall.

The single ventral valve of this species agrees very well with the New York specimens of the large Helderbergian (Becraft) *Rensselaeria.*

Chonostrophia montrealensis n. sp.

Chronostrophia jerensis n. sp.



EXPLANATION OF FIGURES.*

Figs. *a* and *b*, *C. montrealensis*, *a*, ventral aspect, *b*, surface x5.
Figs. *c* and *d*, *C. jervensis*, *c*, ventral aspect, *d*, surface x5. The lines between the figures illustrate the curvature of the valves.

Of the first species, there are two good ventral valves which agree well with small *C. complanata* as determined by Clarke.[*] The Canadian specimens, however, agree best in size and form, with an undescribed species of the Helderbergian (Becraft limestone) of Port Jervis, New York, but differ in the far fainter thread-like striæ which are arranged as in *Rafinesquina alternata* yet not so distinctly bundled as in *Chonostrophia reversa* Whitfield, of the Onondaga. The Port Jervis species may be known as *C. jervensis,* and is distinguished by its size and flatness, but particularly by the equal, sharply elevated, somewhat undulating, and regularly disposed striæ. It generally has three prominent, slightly diverging, cardinal spines on each side of the ventral beak, but there are also specimens with four spines, and others apparently with but the two lateral ones prominently developed. In *C. montrealensis,* there appear to be four similar cardinal spines.

Chonostrophia begins in the New Scotland zone of the Helderbergian in *C. helderbergiae,* and continues upwards as follows: *C. jervensis* in the Becraft limestone, *C. montrealensis* in the higher Helderbergian, *C. complanata* throughout the Oriskany, *C. complanata dawsoni* in the Gaspé sandstone of Quebec, and *C. reversa* in the Ohio Onondaga (Corniferous).

MIDDLE DEVONIC FAUNA.

It has been stated (p. 248) that in the grassy slope and above the Helderbergian rocks in the agglomerate of Saint Helen's island, there is a large block of a slightly granular siliceous limestone containing a few species of brachiopods usually preserved as natural moulds. These fossils were heretofore regarded as of Helderbergian age, but the species are different and indicate a more recent formation. The National Museum collection includes the following forms:

Dalmanella planiconvexa Hall?

> There are three specimens of a *Dalmanella* present, which seem to be much like the Oriskanian variety of *D. planiconvexa.* These orthoids, of the group *D. testudinaria,* are difficult to distinguish unless the material is good, and in the present case, therefore, only the general aspect can be indicated.

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[*] *Memo. N. Y. State Mus.*, iii, no. 3, 1900, pl. 7, fig. 7.

Spirifer macra Hall.

This is the shell referred to by Dr. Ami and the writer as like *S. pennatus*=*S. mucronatus*. The best specimens were collected by Mr. E. Ardley, and are now in the Redpath Museum. The shell differs from the long-hinged Marcellus variety of *S. pennatus* in having a wider ventral hinge area and no distinct bilobation of the ventral medial fold, characters in harmony with *S. macra*. It is closely related to *S. pennatus*, but more directly with *S. macra*, and is considerably removed from *S. cumberlandiae*, of the Oriskanian. There is no shell in the Helderbergian with which it can be compared.

Spirifer cfr. *granulosus* (*Conrad*).

Associated with *S. macra*, there is a more rotund species. with high, slightly incurved ventral area, angular sinus, and prominent dental plates. These are characters associated with *S. granulosus*. At present none of the specimens of this species are at hand, and no identification can be made. However, it undoubtedly belongs to a species in the Middle Devonic.

CONCLUSION.

The foregoing evidence shows clearly that two distinct faunas are represented on Saint Helen's island,—one, the Helderbergian, older than the agglomerate, and another, from a block in the agglomerate, of Middle Devonic age.

The Helderbergian fauna is apparently related with that of New York, and belongs to the facies occurring on the western side of the Appalachian folds. The writer has collected this fauna at Dalhousie, New Brunswick, and from the Gaspé region, Quebec, and both are of another facies and belong to another basin.

The presence of *Rhipidomella* recalling *R. musculosa*; *Spirifer concinnus*; an early variety of *S. murchisoni*; *Spirifer* n. sp., connecting phylogenetically *S. concinnus* and *S. arenosus*; *Camarotoechia pleiopleura*; *Gypidula pseudogaleata*, and *Rensselaeria aequiradiata*, show that the Saint Helen's Island Helderbergian is not as old as the New Scotland zone. *Spirifer concinnus*, and especially *G. pseudogaleata* and *R. aequiradiata* are characteristic Becraft zonal species. However, the

Oriskanian reminders, like, *R.* near *musculosa*, *S. murchison*, *S.* near *arenosus*, prove that the Saint Helen's Island Helderbergian is pretty well up towards the top of the New York section, and may represent both the Becraft and Kingston zones.

Spirifer macra and *S. granulosus* establish the fact that, in the region of Montreal, there was once a formation of marine origin later than the Helderbergian and as recent as the Onondaga* (Corniferous); further, that the agglomerate of Saint Helen's Island and other places about Montreal is not older than late Middle Devonic time. Its age is probably more recent, and there may be further paleontologic evidence in the agglomerate.

REVIEW OF RECENT GEOLOGICAL LITERATURE.

The Calcareous Concretions of Kettle Point, Lambton County, Ontario. By Reginald A. Daly. (*Jour. Geol.*, *8*, 135-150.)

The concretions occur in a horizontally bedded, fissile, black, bituminous shale of middle Devonian age. They are approximately spherical; one to three feet in diameter, and possess a radial crystalline structure. An analysis of one of the concretions shows 88.42 per cent. of calcium carbonate, only 2.99 per cent. of magnesium carbonate, and the remainder consists of iron oxide, insoluble residue, hydrocarbons and water. The most remarkable feature is the mechanical displacement and deformation of the enclosing shales which the growth of the concretions has involved. The pressure or "live force" of the growing concretions or aggregate of spherical radiating crystals has even been sufficient to induce a true slaty cleavage in the shale at some points. The main thesis of the author is to demonstrate that this great centrifugal pressure is compatible with the persistence of the capillary film investing the growing crystal or concretion and without which its continued growth would be impossible. The explanation, which, it would seem, must be generally accepted, is based upon the experiments of Jamin leading to the conclusion that equilibrium may exist between two unequal pressures affecting the ends of a capillary tube, provided a column of liquid occupying the tube be interrupted by bubbles of air. The presence of the latter excites capillary attraction which is so strong as to take up several atmospheres of pressure applied at one end of the tube. The force so expended is represented in the compression of the air bubbles and in changing the form of the air menisci; surface tension is thus overcome. The movement of the bubbles progressively decreases in the direction of the greater pressure until one is reached which is not disturbed at all so long as the pressure remains constant. The bubbles act like so many buffers. Any capillary tube filled with water interrupted by any insoluble gas or liquid possessing a lower surface tension than water, will exhibit the same phenomenon. W. O. C.

The Granitic Rocks of the Pike's Peak Quadrangle. By EDWARD B. MATHEWS. (*Jour. Geol., 8,* 214-240.)

The granites are regarded as of late Algonkian age; and four types are recognized, differing markedly in texture but agreeing closely in mineral and chemical composition. They are typical biotite granites, in which hornblende rarely occurs; and a mechanical analysis of the coarse Pike's peak type gave: quartz 33.4 per cent; microcline, 53.3; biotite and all minerals with specific gravity above 3.0, 10.7; and oligoclase, 2.6; total, 100.00. The petrographic descriptions are accompanied by tables showing for the different types the relative abundance of the sixteen component minerals, and the relative size and development of the three essential constituents. Strangely enough, fluorite, which occurs in three of the four types and is very marked in the Summit type, is not mentioned as a constituent of the Cripple Creek type, notwithstanding its prominence as a feature of the Cripple Creek ore deposits. Another table gives the chemical composition of all but the Cripple Creek type, in four of Hillebrand's complete and careful analyses, with determinations of seventeen constituents. When the individual analyses and their average are reduced to molecular proportions and compared with analyses of other granites, the Pike's Peak granites are seen to be exceptionally rich in silica and potassium, as well as in fluorine; and the family likeness of these types suggests their origin in a common magma relatively rich in the elements named. Although this tends to make the relative ages of the types of little moment, it may be noted that on page 223 the Pike's Peak type is described as clearly the oldest; while on page 228 this distinction is assigned to the Summit type. The reviewer's observations in this field suggest the advisability of regarding the Pike's Peak type as the normal granite of the batholith; the Summit type and the Cripple Creek types as representing a once-continuous contact zone of the batholith, in which the remnants of the Algonkian cover chiefly occur; and the fine-grained type, which occurs only as dikes in the other types, representing residual magma intrusive in shrinkage and other cracks. According to this view the contact-zone types are the oldest and the fine-grained or dike types the youngest, while the Pike's Peak or normal type is intermediate, having solidified after the contact zone by which it is covered and before the dikes by which both it and the contact zone are intersected. As might be expected, the gneissoid phase is chiefly characteristic of the outer or border portions of the massif.

W. O. C.

Geology of the Little Belt Mountains, Montana, with notes on the Mineral Deposits of the Neihart, Barker, Yogo and other Districts. By WALTER HARVEY WEED. *Accompanied by a Report of the Petrography of the Igneous Rocks of the District.* By L. V. PIRSSON.

(*Twentieth Annual Report U. S. Geol. Survey.* Part III pp. 257-581. With 42 plates and 43 figures.)

The stratigraphy represents the same general conditions that are found in the rest of the eastern part of the Rocky mountain area of this state. One feature of especial importance is shown in the Little Belt area, namely, the overlap of the Cambrian beds from the Algonkian in the south to the Archean in the north.

The present structure and altitude of the Little Belt mountains are due to an uplift and folding of the range as a whole, accompanied by a contemporaneous intrusion of large igneous masses producing minor folding and faulting. The principal peaks are igneous and present a variety of types. Sheets, laccoliths, and bysmaliths are found, all three forms grading into one another. Mr. Weed discusses at some length the origin of such intrusions, concluding that in this region the form is a function of viscosity of lava, of resistance of overlying beds, and of the ascensive force.

At least two periods of igneous activity preceded the uplift of the range. The uplift was accompanied by a third period of activity, which was immediately followed by the formation of fissure veins in which the ore deposits occur. Inferentially these ores are believed to be post-cretaceous. Secondary enrichment has played an unusually important part in the development of some of the ores.

Professor Pirsson's report embraces a detailed description of the petrography of the region, and a discussion of analysis and of estimated mineralogical composition. He classifies the igneous rocks into four groups:

a. Granular nonporphyritic rocks, of plutonic origin, including syenites, monzonites, diorites and shonkinites. Yogo peak shows, as part of a single geologic mass, monzonite grading into syenites on the one hand and into shonkinite on the other. This connection is interesting in that it exhibits in the field the grouping which Brögger has suggested on theoretic grounds. Monzonite is not uncommon in the west, appearing in company with either more feldspar or more basic types, and represents the portion of mean composition in a differentiated complex.

b. Acid feldspathic porphyries, the predominant rock of the laccoliths and of a considerable portion of the dikes and sheets. These rocks present many transitions, the transitional masses being often of more importance locally than the commonly known types.

c. Lamprophyres, occurring in small dikes and sheets, and including minettes, vogesites, and analcite basalts. Variolitic facies, shown by some of the minettes of this region, is described as of a spherulitic nature. In this interpretation the author agrees with that of Pohlmann for the variolitic facies of the kersantites of Thuringia, and differs from the general explanation of the structure offered by Rosenbusch in his text-book. These minettes afford no evidence of the action of absorbed aqueous vapors, as described by Cross and by Iddings for spherulites in acid glassy rocks.

d. Effusive rocks, consisting of two flows of basalt.

The average composition of all the rocks described is calculated to be that of an acid syenite approaching a monzonite in character. The rocks of the laccoliths here, as nearly everywhere in the Rocky mountain region, are usually porphyritic and acid. They are typical examples of Rosenbusch's granitic porphyritic dike rocks, which are here typically laccolithic. The phenocysts appear to have been formed where they now are, and in no case to have been brought up from greater depths. No differentiation has been noted in the laccoliths. Yogo peak and the porphyries east of it are examples of differentiation in place, the centre of the mass being acid and the periphery basic. The tendency is here shown for acid rocks to be porphyritic, and basic rocks under the same conditions, granular. Chemical composition, not depth of intrusion, is seen to be the determining factor of granularity.

Numerous small syenite-aplite dikes cut the Yogo mass. They represent the acid residuum forced up into the fracture planes of the upper and previously solidified rock.

The report closes with a discussion of magmas by graphic methods, and of absorption of sediments by magmas. The chemical compositions of the Yogo peak rocks are shown to bear a mathematical relation to one another, which points to a common origin.

This area presents no facts in favor of the view that large amounts of sediments may be absorbed by magmas and produce alterations in composition of igneous rocks. I. H. O.

Notes on the Limestones and General Geology of the Fiji Islands, with special reference to the Taw Group. Based upon surveys made for Alexander Agassiz. By E. C. ANDREWS. (*Bull. Mus. Comp. Zool. of Harvard College. Geol. Survey,* vol. v, No. I. Pp. 1-46; with 40 plates.)

This paper represents a more careful examination of some of the problems suggested to Mr. Agassiz in his exploration of Fiji in the winter of 1897-8. Further results brought in by the W. S. F. C. S. "Albatros," yet remain to be worked up. Mr. Agassiz expects shortly to publish a final report upon the islands.

The present paper consists of careful descriptions of the different beds accompanied by excellent illustrations and maps. The islands are a group of atolls which in Tertiary, and again in recent time, were subject to volcanic activity. The limestones are indurated in some localities and soapstone is found. There is a decided excess of igneous over calcareous rock. I. H. O.

Contributions to the Geology of Maine. By H. S. WILLIAMS and H. E. GREGORY. (*Bul. U. S. G. S.* No. 165.)

A report upon the fauna of Maine was greatly to be desired for purposes of comparison between the typical forms of New York and of Canada, and also as a basis of correlation between American and European Paleozoic phases. This paper deals with sedimentary areas in Somerset and Aroostook counties, and with the Aroostook volcanic area.

Part I, by Dr. Williams, deals with the Paleozoic fauna. He describes the fossils from various formations, giving good illustrations, but reserves more detailed descriptions for future publication. In this paper he discusses especially phylogeny and variation. The boundary between Silurian and Devonian was first described in the Welsh series in which transition was from calcareous sediments with a marine fauna to sandstone with brackish fauna. Dr. Williams now determines this boundary for America. The Lower Helderberg in the interior is closely related to the succeeding fauna, because there was no radical disturbance in the marine conditions. It is the Oriskany fauna that shows evidences of a disturbance which ended in uplifting large areas of marine surface; and this formation is to be correlated with the Gedennian of the Rhenish provinces, and with the base of the Old Red sandstone of Great Britain. Thus the Lower Helderberg is to be located positively as Silurian, in spite of the Devonian relationships of its New York fauna. The Gaspé and Square Lake limestones of Maine both contained evidence of New York Lower Helderberg fauna, and both occur below the Devonian boundary line.

It is to be regretted that Dr. Williams does not institute a comparison between the Upper Helderberg fauna and that of the Ludlow beds of England, which represent the typical Upper Silurian as defined by Murchison and Sedgwick. Since the Siluro-Devonian boundary may now be regarded as established for both countries, a comparison between the faunas of equivalent beds would be of interest.

Part II, by Dr. Gregory, deals with the volcanics and clastics of the Aroostook country. Northeastern Maine is essentially a region of sedimentary rocks, yet such igneous rocks as there are, present a number of well defined types, and considerable variation in character. Dr. Gregory discusses fully the general nature, field relations, petrography, and chemical composition of the volcanics. The clastics are classified on a petrographic basis and mapped from this standpoint, their stratigraphic relationships being left until further evidence is obtained. The structure and history of the region as a whole are not touched upon.

Part III consists of a list of localities where outcrops were found, and is a most useful addition to a work of this sort. I. H. O.

Geology in its Relations to Topography. By T. C. BRANNER. With Discussion and Correspondence, *Trans. Amer. Soc. of Civil Engineers*, XXXIX., pp. 54-95.

Complaints are often heard from geologists of the inaccuracy of maps. Mr. Branner strikes at the root of this matter in showing the necessity of geological knowledge for a successful topographer. There is at present no physiographical text book adapted to the needs of engineers and it is to be hoped that some expert in geology or geography will soon meet this demand. Mr. Branner's paper contains a short account of some of the simplest physiographic features and supplies in untechnical language valuable information in regard to a few of the problems which confront engineers. I. H. O.

Researches on the Visual Organs of the Trilobites. By G. LINDSTROM. Six Plates. (*Kongl. Svenska Vetenskaps Akad. Handl., Bd.* 34. *No.* 8.)

This is a most important contribution to the biology of the trilobites. First, because it challenges proof of the presence of eyes in many species that are supposed to have had visual organs, denying that the structures that have been taken as such are eyes. And secondly because it announces the discovery of true eyes on the hypostonæ of many species.

Lindström claims that the assumption that because a trilobite had an "eye lobe" it therefore had eyes is quite without foundation, for he teaches that this "eye lobe" is due to the impact of the free-cheek at this point with the inner cheek, and he states that in a number of species which he has examined there is no space for an eye between the two pieces of the head shield which there come in contact. The oldest genera with true eyes on the cephalic shield, which he recognizes, are such of the Upper Cambrian, as Petiera Sphœrophthalmus and Ctinopyge. In the Ordovician, Silurian and Devonian, the genera in which true eyes exist on the head shield, are multiplied. There is an interesting discussion on the origin of the facial suture with applications in Olenellus, Paradoxides, Liostraeus, Solmopleura, etc. He does not recognize the presence of eyes or a suture in Agnostus.

Most interesting to palæontologists is the announcement that the tubercles or, as Mr. Lindström calls them, the "maculæ" in the anterior furrow of the hypostome, as seen in many species, had ocular properties. Not only by the thinness of the skin over these spots, but by the actual presence of lenses in them, has he proved that the maculæ in many species possess this office. This discovery of this condition of the maculæ was made by his draftsman and assistant, Herr G. Liljevall. Many trilobites, it would thus appear, had eyes below as well as on the upper side of the headshield.

This important memoir is fully illustrated with six admirable plates and several text figures; in the former the admirable handiwork of Herr Liljevall is patent.

That this work is founded on abundant material may be assumed when it is stated the hypostomes of thirty-six species of trilobites have been sectioned for investigation. These range from the Cambrian to the Devonian.

Herr Lindström considers that the trilobite eye is best represented in that of Apus and the Isopod. G. F. M.

CORRESPONDENCE.

ON THE AGE OF CERTAIN GRANITES IN THE KLAMATH MOUNTAINS. [Abstract.] Small batholyths and dikes of granite, quartz-mica-dioryte and intermediate types are shown to occur at various places in the Klamath region, but in areas quite subordinate in extent to those of the metamorphic rocks in which they have been intruded. The same region contains extensive areas of serpentine, and instances are given of the granitic rocks having been intruded into the serpentine to prove that the granites are newer, in accordance with the determined relations of these rock types in the Sierra Nevada region, and the reverse of the supposed relation between the granite and serpentine of the Coast ranges.

The black slates of the Klamath region are divided into two distinct series, referred to as the lower slates and the upper slates. The former are considered Devono-Carboniferous in age, being in part equivalent to the Calaveras formation. The latter are correlated, on the evidence of their lithology and their structural relations, to the lower slates and to a certain extrusive greenstone formation of the Sierra Nevada region, with the Mariposa formation of late Jurassic age. The intrusion of granite occurred later than the deposition of these upper slates. Also it is shown that the granites are much older than the Chico formation resting on them as they must have suffered much erosion prior to the Chico epoch.

It is finally concluded that the weight of evidence places the granitic intrusion just about at the close of the Jurassic period. The effect of the agreement is to show that there is a sound basis for the inference heretofore entertained that the Klamath mountains belong rather to the same system as the Sierra Nevada instead of the Coast ranges, and may be considered a sort of out-lier to the former.

Berkeley, Cal. OSCAR H. HERSHEY.

A NATIONAL MUSEUM FOR CANADA. The growth and progress of the work done by the staff of the Geological survey of Canada have reached that point in the history of this classic state institution, which dates from 1842, when the headquarters and museum on Sussex street have become not only over-crowded and limited in accommodation, but also positively unsafe. The mass of specimens displayed has long ago reached its crisis, and special orders from the Honorable the Minister of Public Works have compelled the Museum proper to be lightened as far as possible. Besides this, a large series of wooden posts—in the neighborhood of sixty—have been placed at proper intervals on three floors to act as so many props and supports for the collections of ores, minerals and rocks of economic value, etc., in the Dominion of Canada. The building now occupied by the Staff and Museum is totally inadequate for the requirements of the times. It is practically impossible and unsafe to exhibit any discovery made or record the numerous finds and donations received in a tangible or accessible manner. There are thousands of specimens in the possession of the Geological Department which are rendered quite inaccessible, owing to lack of space, and an effort is now being put forth towards obtaining a suitable and fire-proof building in which the products of the earth in Canada, whether as regards its mines, forests, and waters, will be exhibited to advantage.

In looking over the Report of the U. S. National Museum, drawn up by the Acting Assistant Secretary, the Hon. C. D. Walcott, the various divisions and subdivisions of work are given in such a manner as to indicate clearly the line in which it is confidently expected that, at no distant date, the politicians of Canada will see to it that a National Museum will be established at Ottawa, properly equipped, manned and maintained.

It is an urgent necessity that a Central Bureau of *scientific,* in other words, *exact* information exist, where not only reports upon all kinds of subjects can be obtained from specialists, but where a record is kept of information gathered and specimens obtained during explorations, researches, and studies, in connection with the natural resources of half a continent.

The incalculable value of the National Museum to the United States has been recognized by Congress, and it is hoped that Canadian statesmen will see that before long a suitable office and museum buildings be erected, and a thoroughly equipped and efficient staff established, so that the wonderful natural resources of Canada may be exhibited to advantage and carefully published for the information of all.

H. M. AMI.

Geological Survey of Canada, Ottawa, Feb., 1901.

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PERSONAL AND SCIENTIFIC NEWS.

Mr. H. E. Gregory has been promoted to be assistant professor of physical geography at Yale University.

Dr. W. B. Scott, professor of geology in Princeton University, expects to leave for South America, especially for Patagonia, in May.

Mr. E. J. Garwood has been appointed to the Yates Goldsmid chair of geology and mineralogy at University College, London, to succeed Prof. T. G. Barney.

Geological Society of Washington. At the meeting of March 13th, the following was the program: "The Soil Survey of Cecil county, Maryland," by C. W. Dorsey; "Discussion of geologic units: formation, stage and age," by Bailey Willis, H. S. Williams and others.

Geological Society of Washington. At the meeting of March 27th the program consisted of the conclusion of the discussion of geological units, by Messrs. H. S. Williams, C. R. Van Hise, T. C. Chamberlain and others.

Mr. James Bennie, formerly of the Geological Survey of Scotland, died on January 28th. He contributed papers to the Transactions of the Geological Societies of Edinburgh and Glasgow, and two years ago was awarded the Murchison fund by the Geological Society of London.

Geological Survey of Great Britain and Ireland. Mr. J. J. H. Teall, president of of the Geological Society of London, has been appointed director to succeed Sir Archibald Geikie, who retired on February 28th after 46 years of service on the Survey.

School Science is the title of a new journal devoted to science teaching in secondary schools. It is edited by C. E. Linebarger and published at Unity building, Chicago. There is a corps of associate editors, among whom are E. C. Case (Geology) and Wm. H. Snyder (Geography).

Thomas Benton Brooks died on Nov. 22, 1900. Major Brooks was a well-known worker in American geology, and the work for which he will be most frequently praised is that which he did in the iron districts south of lake Superior. In *Science* for March 22nd Mr. Bailey Willis gives a sketch of Major Brooks.

Dr. Robert Bell, M. D., L.L. D., F. R. S., F. G. S. has been appointed director of the Geological Survey of Canada, *vice* G. M. Dawson, deceased. It is understood that Dr. Bell will soon be officially gazetted as "director" of the Canadian [illegible] had been engaged for many years [illegible]

[illegible] at the hour of [illegible] in 1875, and [illegible] had been attending [illegible] energy and enthusiasm up to [illegible] day of twenty-four hours [illegible] A notice of his life and [illegible]

[illegible] MINES.—We have been [illegible] anthracite coal in the West than a [illegible] of special interest. Stopping [illegible] station in New Mexico [illegible] stepped off to examine [illegible] a well and deeply developed mine [illegible] village around the works of many substantial [illegible] 800 inhabitants, with an [illegible] plant and a large coal breaker of thoroughly eastern [illegible] pattern.

The Cerrillos mountains are a small group of hills some [illegible] of Albuquerque city, New Mexico. They are formed of a central core of eruptive porphyritic rock surrounded by a series of upturned sandstones of the Laramie Cretaceous coal-bearing series. Into these strata many dikes and intrusive sheets of porphyrite have been intruded, emanating from the parent core. The heat from these eruptive sheets, where they have come near enough to the coal, has metamorphosed the coal into anthracite. Coal beds not so influenced in the same region remain unchanged as bituminous coal, consequently there are two classes of coal worked near one another. One a four foot six inches seam of bituminous coal and another, some 50 to 75 feet below, of three feet six inches to four feet of anthracite overlain by a thick intrusive sheet of eruptive porphyrites. (*Mines and Minerals.*)

THE PALÆONTOGRAPHICAL SOCIETY announces that monographs of the following groups of fossils are in course of preparation, and will be published by the Society: the Carboniferous Lepidodendra, by Dr. D. H. Scott; the Cycadeæ, by Mr. A. C. Seward; the Graptolites, by Prof. Lapworth, assisted by Miss Elles and Miss Wood; the Fishes of the Chalk, by Dr. A. S. Woodward; the Reptilia of the Oxford Clay, by Dr. C. W. Andrews; and the Cave Hyena, by Mr. S. H. Reynolds. The volume issued by the Society for 1900 contains the Cretaceous Lamellibranchia, by Mr. H. Woods; the Carboniferous Lamellibranchia, by Dr. W. Hind; and the Carboniferous Cephalopoda of Ireland, by Dr. A. H. Ford. (*Nature.*)

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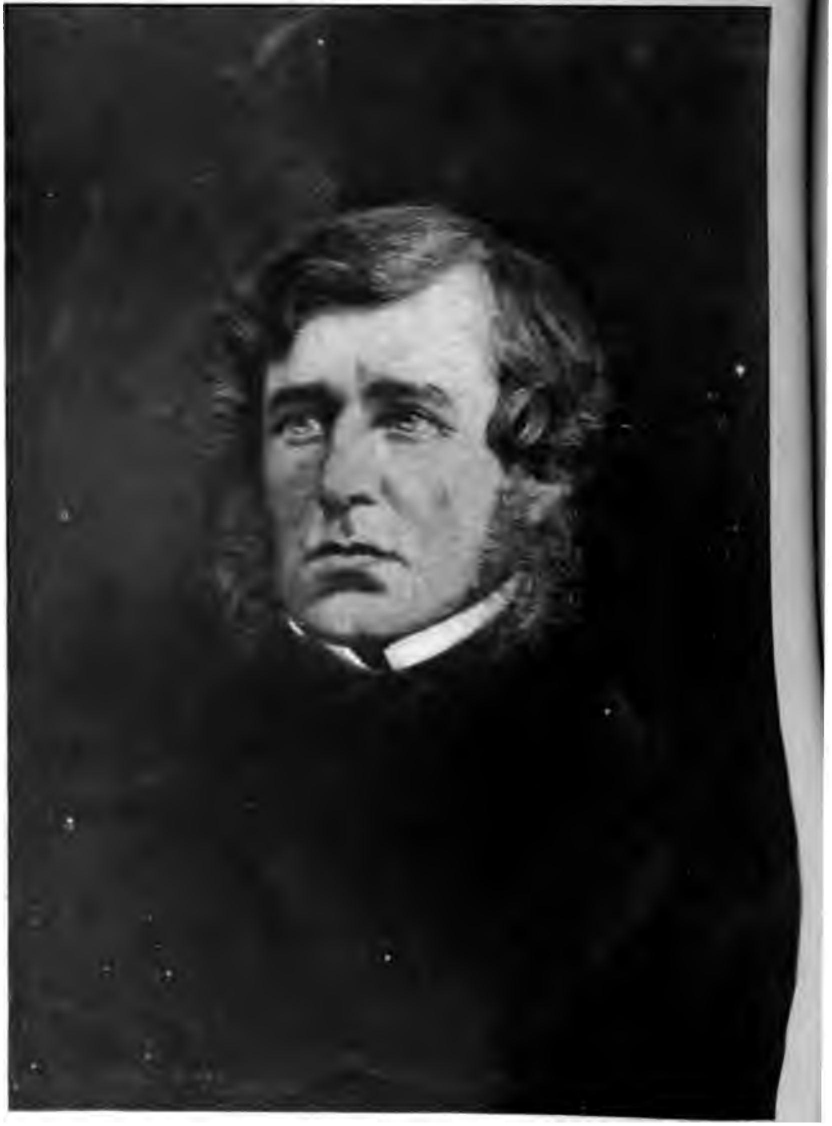

E. Billings.

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BRIEF BIOGRAPHICAL SKETCH OF ELKANAH BILLINGS.

Palaeontologist to the Geological Survey of Canada from 1856 to 1876.

By HENRY M. AMI, Ottawa, Canada.

The late Elkanah Billings, who for twenty years was paleontologist to the Geological Survey of Canada, and was the founder of the Canadian Naturalist and Geologist, was born in the township of Gloucester, along the right bank of the Rideau river in the old, and now demolished Billings homestead situated a few yards below the present bridge which spans that river at the little village of Billings' Bridge. He was the second son of Mr. Bradish Billings, whose ancestors came from England, while those on his mother's side came from Wales. His grandfather was a Brockville physician, Dr. Elkanah Billings, after whom the subject of this sketch was named. Both his parents, however, were born in the United States, his father in Massachusetts, and his mother in New York state.

From Dr. Whiteaves' obituary notice of Elkanah Billings the following extracts are made:

"Elkanah Billings, our esteemed associate for so many years, was born at the family homestead on the 5th of May, 1820. His first teacher was a governess (Miss Burrit), his next a family tutor named Maitland, and he afterwards went to three small schools in the neighborhood, kept respectively by Messrs. Colquhoun, Collins and Fairfield. In 1832 the youth was placed at Rev. D. Turner's school in Bytown, as a day pupil and after four years' interval, during which he remained at home on the farm, his parents sent him, in 1837, to [illegible] principals.

[illegible] Mr. Billings entered the law [illegible] as a student in 1839, and was [illegible] barrister in Bytown. Mr. [illegible] same year and was succeeded by Mr. [illegible] Mr. Billings remained for nearly [illegible] appears that he was for a short time also [illegible] Mr. George Byron Lyon Fellowes [illegible] Toronto, and studied for [illegible] legal firm of Baldwin & Wilson [illegible] practice as an attorney in the fall of [illegible] returned to Bytown and entered into partnership [illegible] Armstrong, who was the [illegible] but a law having been passed [illegible] judges from pleading, the partnership was dissolved after having lasted only six months."

In 1845 Mr. Billings married a Toronto lady, a sister of [illegible] Wilson. Between 1845 and 1848, he practised law in Bytown, having been called to the bar in [illegible] he removed to Renfrew where he practised [illegible] until June, 1852, when he returned to [illegible] his time was engaged in journalistic and [illegible] pursuits. He occupied the editorial chair of [illegible] from the fall of 1852 until late in 1855. Many of Mr. Billings' leading articles in the *Citizen* of those days comprised popular disquisitions on geological topics and natural history subjects, which served to indicate the trend of thought of the man whose subsequent life led him into investigations of the highest scientific type, whose writings are now held in highest esteem and well known the whole scientific world over. It was during these years of his residence in Bytown that he began the systematic study of the fossiliferous rocks which are so extensively developed along the banks of the Ottawa river in the vicinity of our city.

Probably at first entered upon more as a pastime and relaxation from his journalistic duties these researches culminated in his final adoption of geological studies, especially in the department of fossil organic remains, for the remainder of his life.

The magnificent collections of Crinoidea, Cystoidea and Asteroidea from the Trenton limestone of Ottawa, that are now exhibited in the museum of the Geological Survey of Canada, testify to his remarkable success and energies in these researches, for it must be remarked that these organisms are exceedingly rare and great diligence as well as patience must be exercised if satisfactory results are to be obtained.

Early in 1856 Mr. Billings issued the first number of the *Canadian Naturalist* of which, and the succeeding numbers of the first volume, he was practically the sole contributor. The production of this number marks an epoch in the history of the progress of scientific research and discussion in Canada. The articles contained in the first volume of the *Canadian Naturalist and Geologist* at once stamp Mr. Billings as a master in description both of fossil organic remains and of recent natural history objects.

Previous to the issue of this magazine, Mr. Billings had been brought into direct communication with Sir William Logan, then director of the Geological Survey of Canada, and it was not long, yea, but few months elapsed, until the latter with his usual clearsightedness engaged the services of Mr. Billings, his friend, as paleontologist to the Geological Survey of Canada. It was in August, 1856, that Mr. Billings entered upon his duties as government paleontologist and, until his death, which took place June 14, 1876, a period of nearly twenty years elapsed in which he worked ceaselessly in the domain of paleontology, and in assisting his chief and director in assigning geological outcrops to the various geological horizons of eastern Canada, involving numerous and difficult problems which made it a task of no mean importance.

His first geological paper was published in April, 1854, and was entitled "On Some New Genera and Species of Cystidea from the Trenton Limestone." It was published in the Canadian Journal, Toronto, page 215. On removing to Montreal in 1856, Mr. Billings removed also the headquarters of his magazine. *The Canadian Naturalist and Geologist,* from that date on was published in Montreal under the same designation and under the name of *Canadian Naturalist and Q. J. So.,* until 1883, when it was superceded by the *Canadian Record of Science,* and became the recognized official organ of the Natural History Society of Montreal. Of this society he was regularly elected a vice president for 14 years, having declined the office of president, proffered to him on many occasions.

In 1858 Mr. Billings made a visit to Europe, where he came in contact with leading geologists of the time and examined various collections in geology in Great Britain. These he studied most zealously and made a comparison of the Silurian (including both the lower and upper Silurian of Murchison) and Devonian fossils of western Europe, with those of Canada, and arrived at the conclusion that there were but few species identical with those of Canada. In April, 1858, when in London, he was elected a fellow of the Geological Society of London; Sir Roderick Murchison, Professor A. Ramsay and Professor T. H. Huxley, having nominated him. He visited Paris where he met a number of distinguished men, amongst others the great Bohemian paleontologist, the Abbe Joachim Barrande, with whom and in conjunction with Sir William Logan, a most interesting discussion arose regarding the age of several rock formations occurring in the province of Quebec, to which Sir William Logan gave the name "Quebec Group"—a controversy which included many difficult problems of which the "Taconic Question" was a conspicuous factor.

The term "Quebec Group" will invariably be associated with the excellent work performed by Sir William Logan and Mr. E. Billings.

In 1854, two years before his appointment on the Geological Survey staff, Mr. Billings accompanied Mr. James Richardson in an examination of the fossiliferous rocks of Point Levis, Que.; in the following year he also accompanied the same field geologist in his explorations at Point Levis, Que., and Thetford, in the township of Bosanquet, County of Lambton, Ontario.

Of Mr. Billings' work prior to 1863, Sir William Logan gives the following succinct account on page 7 of the "Preface" in his "Geology of Canada," published in 1863:

"Mr. Billings was appointed paleontologist to the survey in 1856 and since then his unremitting attention has been devoted to the study of the palaeozoic fossils of Canada, of which very considerable collections have been made in our various explorations.

"Of these fossils he has described in the publications of the survey and in the scientific journals of the province, 526 species, of which 395 are Lower Silurian, 67 Middle and Upper Silurian, and 64 Devonian.

"He has thus greatly facilitated the means of determining with precision the limits and distribution of our geological formations, and of the economic substances which they contain. In order to insure uniformity in the paleontological part of this work, all the palaeozoic fossils mentioned in it have been submitted to the inspection of Mr. Billings, and the species are therefore all given on his authority. Of the described Lower Silurian species found in Canada, not including those of the Quebec group, he has prepared a catalogue, showing their vertical distribution, and referring to the publications in which the descriptions and figures will be found. This catalogue has been introduced into the appendix to this volume."

Then after a brief sketch of the early studies made by himself in the "Quebec Group" of rocks, Sir William points out what part Billings played in the unravelling of that interesting succession of palaeozoic sediment. He goes on to say: "But the discovery in May, 1860, of the Point Levis fossils at once enabled Mr. Billings to conclude that the rocks of the Quebec group must be placed near the base of the second fauna of Barrande or about the horizon of the Calciferous and Chazy formation. This opinion, our subsequent investigations in the neighborhood of Lake Champlain, and of the Strait of Belle Isle, have completely borne out, and there now remains little doubt that the attitude of the rocks in question in the vicinity of Quebec is due to a great overlap, which runs from southwest to northeast through the whole length of the eastern part of the province, and extends in both directions far beyond it."

The above serves to show clearly the remarkable work done by Billings in that most difficult field east of the great Champlain, St. Lawrence or Appalachian fault.

His critical eye detected differences where they had not been seen and by his knowledge the vertical range of fossil remains was firmly established.

Notwithstanding all the attacks that have been made upon the validity of the term "Quebec Group," and the discussions on its significance, it is as truly a natural group or division in the succession of paleozoic sediments in eastern Canada today as it was in the 50's and 60's, and the chapters devoted to this most important study in the "Geology of Canada" for 1863, are replete with wisdom and forethought.

On several occasions Mr. Billings made extensive collections in the Silurian as well as in the Devonian formations of Ontario and in the vicinity of Montreal, as can be seen from the collections now in the geological department, but the bulk of his time was devoted to the determination of geological horizons for mapping purposes and the description of new genera and species brought in to the department by the various field-geologists. Of genera new to science, Mr. Billings described no less than 61 and in all described 1,065 new species of fossil organic remains from various horizons in the paleozoic of Canada. He also contributed many papers on natural history and zoology.

He did much in assisting Sir William Logan to establish and build up the geological museum, for, besides the large number of new species which he described, he identified as many more, from Canada, with forms previously described by Conrad, Hall, Emmons, Vanuxem and Sowerby, and other paleontologists of America and Europe.

His writings indicate a clear and precise mind, coupled with a rare judgment; they are couched in a phraseology simple but to the point. He published upwards of 170 distinct papers, memoirs or reports, many of which are now very difficult to obtain or entirely out of print. The bulk of his writings are embodied in the reports of the Geological Survey of Canada, comprising the figures and descriptions of "Canadian Fossil Organic Remains," or Decades 1, 3 and 4; the "Paleozoic Fossils," Vol. 1, parts 1 to 5; Pal. fos., Vol. 2, part 1; part 2 of which last is still unpublished. While residing in Montreal he was a constant contributor to the Canadian Naturalist, he also wrote important papers for the *American Journal of Science and Arts*, New Haven, the *Geological Magazine,* London, and the *Journal of the Canadian Institute,* Toronto.

He was an indefatigable worker: from early morning till late at night he was at his desk, and later at home into the hours of night he carried on his studies, and thus accomplished much in those twenty years of official connection with the Geological Survey of Canada.

Billings left behind him a large amount of unfinished work, numerous and important lists of organic remains bearing upon the geology of the older provinces. Many of these lists would form most important contributions to Canadian geology, should they ever be published. As noted by Dr. Whiteaves in his obituary sketch and *In Memoriam* paper, Vol. 8, No. 5, *Canadian Naturalist and Quarterly Journal of Science,* p. 261, "Mr. Billings died before he could describe the whole of the material he had studied and carefully examined, including collections by Sir William E. Logan and Professor (now) Dr. Robert Bell, in Gaspe, by Mr. T. C. Weston, at Arisaig; T. Curry, at Port Daniel and Bay of Chaleurs. The whole of the material from these localities had been carefully examined, and it only remained to write the descriptions of the different species, but this, alas, he was not destined to accomplish." Those who had the pleasure and privilege to know Mr. Billings, state that he was characterized "by great firmness and decision and an unswerving love of truth and justice, and by an unaffected and winning modesty of demeanor."

During his lifetime Mr. Billings received many tokens of appreciation. In 1867 the Natural History Society voted him its silver medal for "his life-long efforts for the promotion of science in Canada." He was awarded a bronze medal (in Class I.) by the jurors of the International Exhibition of London in 1862, and a similar one at the Paris Exposition of 1867.

To do him honor and indicate to the world of science what Billings did for Canadian geology, many a paleontologist in America and Europe has described genera and species after him. The genera Billingsia, Billingsite, Billingsella and Elkania have been erected by Walcott, Hall, Ford and Hyatt, whilst upwards of thirty species of corals, crinoids, brachiopods, lamellibranchs, molluscs, cephalopods, ostracods, trilobites and other fossil organic remains bear his name.

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3. On the Genus Stricklandinia, with descriptions of the Canadian species. pp. 78-89.

4. Notes on the structure of the Crinoidea, Cystidea and Blastoidea. pp. 90-128.
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ORIGINAL MICACEOUS CROSS-BANDING OF STRATA BY CURRENT ACTION.

By J. B. Woodworth, Cambridge, Mass.

The process of sedimentation normally produces layers of uniform texture parallel with the surfaces of the laminae. Bands of different mineralogical and textural characters inclined to the planes of stratification are common in the metamorphic rocks as the result of mineralization of shear zones or of the brecciation and mineralization of shear zones inclined to the original sedimentation planes. The following description relates to a case in which a micaceous banding occurs as an original structure at a high angle with the stratification imitating the dual structure of some metamorphosed sediments.

The Fitchburg railroad one and a half miles east of Concord, Mass., occupies a deep cut through a rude glacial sand-plain which encloses lake Walden. In a side cutting in this excavation, the writer observed in 1898 a bed of fine, brown glacial sand about one foot thick sharply demarcated from clays and sands above and below by certain peculiarities of structure and texture. This layer was very regularly beset by current-mark with westward facing steeper fronts, indicating the drifting of the sediment in that direction during deposition. The crests of the ridges were regularly superposed, each successive layer having its crests at regular intervals somewhat advanced to the westward upon the underlying one, giving a crest plane inclination for the series of about 45° east.

The striking feature of the bed was a band of highly micaceous sands forming the frontal slopes of the entire series of crests in the bed as shown in the annexed figure, by the shading.

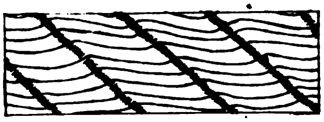

FIG. I. CROSS-SECTION OF A PORTION OF THE LAKE WALDEN GLACIAL SAND BED, SHOWING A CURRENT MARK WITH MICACEOUS BANDS IN THE FRONTAL SLOPES OF THE CRESTS.

The micaceous bands were about half an inch in width. They dipped 45° east, as stated above, parallel to planes passing through the respective crests. The individual particles of mica lay parallel to the crest slope, producing an obvious false bedding totally distinct from the straticulate structure of normal cross-bedding in relatively homogeneous sands. The micaceous bands were between four and five inches apart.

The type of rippled stratification with which the micaceous banding was associated shows that the banding developed under the action of the vortical movements of the bottom drift of a slowly moving current. In analogy with the observed vortices of a continuous bottom current, my colleague, Dr. Jaggar, suggests the whirling movement of the water must have been as in the annexed figure at the crest of each current mark. (See fig. 2.) In the dead space on the frontal slope, particles of mica which were caught in the bottom movements would come to rest as the deposit grew upward.

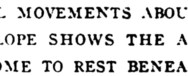

FIG. 2. SCHEME OF VORTICAL MOVEMENTS ABOUT THE CREST OF A CURRENT MARK. THE SHADED SLOPE SHOWS THE AREA ON WHICH THE PARTICLES OF MICA HAVE COME TO REST BENEATH THE NODE JUST IN ADVANCE OF THE CREST. (AFTER SKETCH BY JAGGAR.)

In this connection, it will be recalled that Spurr in this Journal (vol. xiii, 1894, pp. 43-47, 201-206, with discussion by Jaggar, pp. 199-201), described a rhythmic succession in texture parallel to the stratification resembling current or ripple mark, but the textures were pebbly and sandy. In the Minnesota glacial deposit described by Spurr as in this case a cross-banding was produced at about 45° to the true stratification. Of the structure described by Spurr, the writer has seen no examples and is therefore unable to make further comparison of the two cases.

It will be noted that the simulation of the banding of metamorphic schists in the lake Welden case is remarkable, and if the deposit existed as a firmly consolidated, slightly metamorphosed rock, it might be on hasty examination mistaken for an ordinary deposit with its banding induced by the production of new minerals. Where metamorphism and the production of micaceous minerals take place without shearing as in the quartz-albite-biotite rock of the "Devil's foot ledge" in the Carboniferous of Kingstown, Rhode Island, the secondary mica may lie in the original planes of stratification, including those of the cross-bedding. Moreover, it is conceivable that the metamorphism of a bed like that at lake Walden under static conditions without deformation might lead to the retention of the essential arrangement of the original particles. The writer is not aware, however, that any known mica-schists or quartz-mica-schists exhibit evidence of this original distribution of their mineralogical components.

An analogous but not homologous structure exists in the diagonal fissility of Van Hise in certain sheared and mineralized sediments. Thus in the carboniferous gneissoid sandstones of Prudence Island in Narragansett Bay, these bands of compact mineralized layers of arenaceous sediments alternate with thicker layers of finer sediments less mineralized but beset by open planes of diagonal fissility inclined about 45° to the bedding, this secondary structure occupying relatively to the mineral banding the position held by the original bedding planes to the micaceous banding in the glacial deposit above described.

A HISTORICAL OUTLINE OF THE GEOLOGICAL AND AGRICULTURAL SURVEY OF THE STATE OF MISSISSIPPI.[*]

By E. W. HILGARD,[†] Late State Geologist, Berkeley, Cal.

The geological and agricultural survey of the state of Mississippi had its origin in an act of the legislature entitled "An Act to further endow the University of Mississippi," approved March 5, 1850, which took effect on the first of June following. This act is worded as follows:

SEC. 1. *Be it enacted, &c.*, that the further sum of three thousand dollars be and the same is hereby semi-annually appropriated, subject to the draft of the President of the Board of Trustees of the University of Mississippi, to be applied by them to the purchasing of books and apparatus, and the payment of the salaries of professors and assistant professors of agricultural and geological sciences in said University; provided that one-half only of the amount of said appropriation shall be from the revenue in the treasury, and the other half shall be made out of the sale of lands belonging to the seminary fund hereafter to be sold as provided by law.

SEC. 2. That the authority required by the State Treasurer for the payment of the trustees, shall be the warrant of the President of the Board of Trustees, drawn in favor of any person whatever.

SEC. 3. That at least one-half of the amount herein appropriated shall be expended in making a general geological and agricultural survey of the State, under the direction of the principal professor to be appointed under the first section of the Act.

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[*] Reprinted from the publications of the Mississippi Historical Society.

[†] Professor Eugene Woldemar Hilgard was born in Zweibrücken, Rhenish Bavaria, Jan. 5, 1833. He emigrated to America in 1836. After completing his collegiate education at Belleville, Ill., he took the degree of Ph. D., at Heidelberg in 1853. He also studied at Zurich, and at Freiberg, Saxony. The degree of LL. D. has been bestowed upon him by Columbia University, the University of Michigan, and the University of Mississippi. He was state geologist of Mississippi from 1855 to 1873, during which time he filled the chairs of Geology and of Chemistry successively. In 1873 he accepted the professorship of Geology and Natural History in the University of Michigan. After two years' service at this place he went to the University of California as Professor of Agricultural Chemistry and Director of California Agricultural Experiment Station and Dean of the Faculty of Instruction in California. He is at present actively engaged in the discharge of his duty at the University of California, Berkeley, California. In 1860 his *Report on Geology and Agriculture in Mississippi* was published by authority of the State Legislature. This valuable work is still regarded as a standard authority on the geological formations peculiar to Mississippi and the Southwest. In 1880 he directed and edited the work on the report entitled "Cotton Production in the U. S." (10th Census), to which he himself contributed detailed descriptions of the agricultural features of Mississippi, Louisiana and California. In 1894 he received the Liebig medal for distinguished achievements in agricultural science from the Academy of Sciences, Munich, Bavaria.

In 1860 Dr. Hilgard married Miss J. Alexandrina Bello, daughter of Col. Bello, of Madrid, Spain.

In spite of a comparatively feeble body, Mr. Hilgard's vigorous intellect and untiring energy have produced and published a large number of remarkably valuable papers upon topics of scientific interest and relating to a large variety of subjects connected with his wide field of activity.—EDITOR.

SEC. 4. That the survey herein provided for shall be accompanied with proper maps and diagrams, and furnish full and scientific descriptions of its rocks, soils and geological productions, together with specimens of the same; which maps, diagrams and specimens shall be deposited in the State Library and similar specimens shall be deposited in the State University, and such other literary institutions in the State as the Governor may direct; provided that the survey shall be made in every county in the State.

SEC. 5. That the Trustees of the State University shall cause a report to be made annually to the Governor, to be by him laid before each session of the Legislature, setting forth, generally, the progress made in the survey hereby required.

SEC. 6. That this Act take effect and be in force from and after the first day of June next.

Under the somewhat loose provisions and phraseology of this act Dr. John Millington, at the time professor of chemistry at the University of Mississippi, was in June, 1850, appointed to the position and additional duties provided for by it. No assistant was obtained until July 15, 1851, when Oscar M. Lieber, of South Carolina, was appointed to the position. No record or report of Lieber's work was made; during a portion of his incumbency (presumably in autumn of 1852), he made, on horseback, a reconnoissance of the Yazoo Bottom; but nothing beyond that fact appears from the letters written by him under the regulation defining his duties, which provides that "When not actually engaged in making explorations and surveys, he shall aid the principal professor of geology, agriculture and chemistry in the discharge of his duties; and while engaged in making such surveys, he shall make reports at least monthly to the principal professor, and the salary of said assistant professor shall be $1,000 per annum." Lieber resigned on January 14, 1852.

In January, 1852, the position was accepted by Prof. B. L. C. Wailes, then of the faculty of Jefferson College, near Natchez. This gentleman had already made a collection of rocks and fossils of the southwestern part of the state, and had quite an extended knowledge of the general features of the latter. There was also passed by the legislature, in session at the time, "an act to amend an act to further endow the University of Mississippi, approved March 5, 1850," the provisions of which are as follows:

SEC. 1. That the fourth section of the above recited act be so amended as to read "Zoological" instead of "Gological" productions.

[illegible] adjoining the State Library [illegible] general [illegible] appropriated and [illegible] part [illegible] and [illegible] such specimens as may be collected [illegible] progress of the geological survey provided for in the [illegible] and [illegible] dollars be appropriated, out of any money [illegible] not otherwise appropriated, to defray the expenses [illegible] and room for the reception of said specimens. [illegible] fitting up of said room shall be done under the [illegible] upon whose requisition the auditor shall [illegible] appropriated, or so much [illegible]

[illegible] fitted in shall be under the [illegible] geological [illegible] shall be authorized [illegible] the same.

[illegible] shall be open to the public during [illegible] now required by law to keep open [illegible] additional compensation [illegible] section of this Act.

[illegible] that by the verbal correction made in [illegible] was practically made [illegible] the only branch not [illegible] might be understood to be [illegible] provisions for an agricultural survey [illegible] had but a very ephemeral exist[illegible] years, viz., 1852 and 1853, [illegible] southern and eastern part of the state [illegible] examining the [illegible] Mississippi and the tertiary and quaternary [illegible] southern part of the state.

[illegible] of tertiary fossils, especially from the shell [illegible] Wailes to Conrad, and mammalian [illegible] other bones from the loess to Leidy, for determination and description, and collections of these and other fossils [illegible] deposited, both at Oxford and at Jackson.

In January, 1854, Wailes presented to the Board of Trustees of the University of Mississippi the manuscript of his report on the work of the two preceding years, which was transmitted through the governor to the legislature, with the recommendation that it be printed. The legislative committee to whom it was referred reported back the following act, which was passed and under which the survey was thereafter carried on for a number of years.

AN ACT

To authorize the printing of the first annual report of the Agricultural Geological survey of the State.

SEC. 1. *Be it enacted by the Legislature of the State of Mississippi,* That two thousand copies of the report of Professor B. C. L. Wailes, State Geologist, be printed under his supervision, in quarto form, and in such manner, and with such illustrations and plates, as his excellency the Governor shall deem appropriate and necessary for its illustration.

SEC. 2. *Be it further enacted,* That when printed and bound the said report be deposited in the office of the Secretary of State, to be by him distributed as follows: fifty copies to be deposited in the State Library; twenty-five copies to be deposited in the State University; one copy to each state in the Union; one copy to be given to each incorporated college and academy in the State; one copy each to the Governor, Secretary of State, Auditor of Public Accounts, State Treasurer, Adjutant General, the Chancellor and Vice-Chancellors, the Judges of the High Court of Errors and Appeals, the Attorney General, the Judge and District Attorney of each District, each member of the present Senate and House of Representatives, and one hundred copies to the said State Geologist, to be by him exchanged for similar reports from other states, and to furnish to scientific societies and public libraries.

SEC. 3. *Be it further enacted,* That one thousand copies of said report shall be deposited in the office of the Secretary of State, to be sold by any agent or agents to be appointed by the Governor, under such regulations and for such sum as he may deem proper and advisable, for the purpose of reimbursing the State for publishing the same, and the balance to be distributed among the several counties of the State, in proportion to their representation in the Legislature, to be furnished to the people thereof, in such manner as the Boards of Police of the several counties may direct.

SEC. 4. *Be it further enacted,* That previous to the printing of said report, it shall be revised and completed by the said State Geologist; and the portion of it which treats of Zoology, as far as prepared, shall be omitted, and in lieu thereof, a catalogue of the fauna of the State, as far as ascertained, shall be substituted.

SEC. 5. *Be it further enacted,* That for the farther and more efficient prosecution of the survey, analyses of the marls, soils, mineral waters, and the chief agricultural productions of the State, shall be made at the University of Mississippi, as the Trustees may designate; and the State Geologist may, from time to time, furnish such soils, marls and waters as may be required for analysis, and shall receive in return from the chemist full and precise reports of all analyses which may be made; and specimens of soils and marls shall be preserved in convenient glass bottles in the State Cabinet and in the Cabinet of the State University, properly labeled with the chemical character of the substance and the locality from which the same was obtained.

SEC. 6. *And be it further enacted,* That the said Geologist shall make collections of specimens to illustrate the mineral character and paleontology of the State, in addition to the zoological productions which by law he is now required to collect, and to cause them to be suitably arranged and preserved in the State Cabinet, and in that of the University; and any duplicates that remain may be distributed by him among such of the incorporated colleges of the State as may apply for them.

SEC. 7. *And be it further enacted,* That a sum not to exceed two thousand five hundred dollars be appropriated out of any money in the treasury, to be drawn upon the requisition of the Governor, for the purpose of carrying into effect the provisions of this Act.

SEC. 8. *Be it further enacted,* That this Act shall be in force from and after its passage.

Approved March 1, 1854.

Wailes' *Report* (the first of the Mississippi geological reports), of which the publication was provided for by the above act, bears the imprint of "E. Barksdale, State Printer, 1854," but was actually printed at Philadelphia, where Wailes remained during the greater part of 1854 to superintend its passage through the press. The volume is an octavo of 371 pages, with 17 illustrations, partly of a historical character, partly referring to the cotton industry; eight illustrate geological subjects, the most important being four plates of shells from the Jackson shell bed, named and described by Conrad. The report begins with a "historical outline" covering 125 pages; a treatise on the agriculture of the state, partly historical and dealing largely with cotton culture, followed by some analyses of marls, cotton ashes and mineral waters, and covering 81 pages; meteorological data, 12 pp.; lists of fauna and flora, 46 pages; appendices, with documents, 25 pages. This summary is sufficiently indicative of the fact that Wailes was not, and did not write as a specialist in any department. He makes no attempt to classify the rocks he describes otherwise than as Cretaceous, Tertiary and Quaternary, and inferentially classes among the latter the sandstone of the Grand Gulf group, which is mentioned as overlying "diluvial gravel." He traces correctly the northern limit of the Grand Gulf rocks from the Mississippi across Pearl river to Brandon, and describes its occurrence in southwestern Mississippi.

It will be noted that although the act of 1854 designates Wailes as "state geologist," it does not create that office, which still remained an appendage of the chair of geology at the University of Mississippi. It was expected that Wailes would be elected to that chair, which in autumn 1853 had been vacated by Dr. Millington. At an election held in June, 1854, however, the choice for that position fell on Lewis Harper.*

Wailes, thereupon, immediately resigned his position, which remained vacant until September, 1855. Up to the summer of 1855 Harper, bearing the titles of professor of geology and agriculture, and state geologist, had not taken the field himself. He was now by action of the Board of Trustees relieved from a portion of his duties as instructor, and directed to take the field personally, for the purposes provided for in the act. Besides, Dr. F. A. P. Barnard, then professor of physics at the university, was requested to secure a competent assistant geologist at a salary of $1,000 per annum, during a contemplated visit to the North. At the Providence meeting of the Am. Ass'n Adv. of Science, August, 1855, Dr. Barnard fulfilled his mission by tendering the appointment to the writer (then lately returned from Europe), who promptly accepted it, amid the sincere condolence of his scientific friends upon his assignment to so uninteresting a field, where the paleozoic formations (then occupying almost exclusively the minds of American geologists), were unrepresented.

On the way south, a few weeks later, I paid a visit of several days to Dr. David Dale Owen and his assistants, E. T. Cox and S. S. Lyon (then engaged in the work of the Arkansas state geological survey), at New Harmony, with a view of obtaining suggestions for the work before me. This visit was most important and fruitful in giving direction to my subsequent studies and methods.

Reaching Oxford about the middle of September, 1855, I found that Harper had then just returned from a rapid reconnoissance of the cretaceous and tertiary prairie regions in eastern Mississippi; and it was agreed that we should as soon as possible set out on a joint exploration over the same route, to be continued to the Gulf shore; thence across the southern counties of the state to the Mississippi river. The start was made early in October, the outfit consisting of an ambulance carrying a camping outfit, and a negro driver, who at the same time performed the office of cook. The cretaceous prairie country on the Tombigby river was reached near Okolona, whence the route lay through Aberdeen to Columbus; thence, leaving the cretaceous territory, through Neshoba and Kemper counties to Enterprise on the Chickasawhay river, and along that stream, crossing all the marine tertiary stages, as far south as Leakville, Green county. It then became apparent that there was not time to reach the coast, as intended, without the risk of being caught in a very remote and thinly settled region, by the early winter. We therefore turned westward at once and reached the Mississippi at Fort Adams, from which point we took steamer passage to Memphis, Tenn.

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*Properly, Ludwig Hafner, of Hamburg, Germany, originally a student of law, who for political reasons had to leave the country before graduation, and subsequently became interested in natural history; then a teacher of natural science at an academy near Greenville, Alabama.

This expedition was made too rapidly and with too few facilities for making collections, to afford anything more than a very general insight into the character and relations of the several cretaceous and tertiary stages. It was shown conclusively that the dip of all the marine tertiary beds is southward, except only as regards the Grand Gulf rocks, whose relations to the rest we had no opportunity of observing, since they are unrepresented in the Chickasawhay section, save by clays of which the equivalence was not then apparent.

Meanwhile it had become apparent to the University trustees that in its present form the survey was in more than one respect a burden to the University; and, accordingly, at the legislative session of 1855-6, Governor McRae, in transmitting to the legislature the regular report of the trustees of the University of Mississippi, accompanies it by a special message in which occurs the following passage:

"The first portion of the trustees' report relates to the geological survey of the state geologist, and proposes the separation of this survey from the University; and asks that it may be taken charge of by the state, as an independent work under the direction of the governor. The reasons for this are fully set forth in the report, and may be recapitulated in brief as follows:

1. The geological survey does not form a part of the course of instruction in the University, and is not properly connected with the business of the institution.

2. The duties of the State Geologist, under the present arrangement, being partly as professor in the University, partly in the field survey,

> neither position can be fully or satisfactorily filled by him. Either the classes in this department must suffer in his absence, or the survey in the field be neglected to give them proper attention.
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> 3. The funds of the University are not sufficient to justify it in bestowing a portion of them on a work, however important and valuable to the State, that is not legitimately a portion of its business.
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> The appropriation by the State of $3,000 annually for the geological survey, pays no more than the salary of the principal and assistant geologists; and the outfit and traveling expenses, &c., amounting to as much more, have to be provided for out of the college funds. This is unjust to the University, and the divided time of the State Geologist between the University and the field, operates injuriously both to the interests of the University and the State. I would not be understood by this, nor would the Board of Trustees, as casting any reflection upon the learned gentleman who now fills the place of State Geologist, and whom they and myself believe to be well and highly qualified for the duties of that station, nor would we have it understood, and the Board of Trustees would not, that we detract in the slightest measure from the great interest and importance to the State of having a geological survey thoroughly and efficiently prosecuted. The object is to place it in the hands of the State and under the direction of her authority, where it properly belongs, and to have it vigorously prosecuted to completion at the earliest day. I therefore recommend to the Legislature, to place it in this position and to provide the means necessary to accomplish this object. It is believed that an appropriation annually, for three years of $6.000, will be sufficient to complete the entire work within that period.
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> The report of Professor Harper, herewith submitted, contains much valuable information—shows a high degree of scientific attainment on his part, and gives evidence that when the work is completed, it will be one of great value to the public. The present report is only preliminary and partial and is not designed for publication at this time, but is to be embodied and published in the general report when completed."

The suggestion of the governor was not, however, favorably acted upon by the legislature; the matter was left in *statu quo*, but with the understanding that a vigorous prosecution of the work should pave the way to more satisfactory legislation at a succeeding session.

After passing the winter at Oxford in the arrangement of the collections and preparations for analytical work, I proceeded in April, 1856, to make a detailed exploration of the northeastern portion of the state, where the geological structure seemed most complex and varied. In the course of this expedition, made with the same outfit that had served the year before, I determined the character, stratigraphical relations and limits of the carboniferous, cretaceous and tertiary beds of that part of the state, making extended collections especially of what was afterwards designated as the Ripley Group of the cretaceous by Conrad.*

I also investigated closely the features and geological relations of the "Orange Sand" (now better known as the Lafayette formation of the Southwest), showing its derivation partly from northern sources, partly from the underlying formations of which it contains the fossils; distinctly characterizing it as a quarternary deposit.

It having become clearly apparent to me by this time that the survey would never maintain itself in public esteem on the basis of mineral discoveries, and that it must seek its main support in what services it might render to agriculture, I made a point of paying close attention to and recording the surface features,† vegetation, soils, the quality and supply of water, and especially the marls, which I found to occur in large supply and great variety. I also made a collection of plants, which, although omitted from the subjects mentioned in the act creating the survey, I perceived was essential toward the characterization of soils. In the prosecution of these studies, the close connection between the surface vegetation and the underlying formations became so striking, that I soon largely availed myself of the former in tracing out the limits of adjacent formations, in searching for outcrops, etc.

I also, by current inquiry among the inhabitants, ascertained all that was known regarding the peculiarities, merits and demerits of the several regions or soils, from an agricultural point of view, and studied their practice and its results on the several soils and crops.

During the latter part of the season of 1856, I extended the detailed survey of the cretaceous area as far south as Columbus; and thence, as the beginning of the rainy season rendered farther field work unprofitable, I drove across the country to Tuskaloosa, Ala., in order to compare notes and consult with Tuomey, then state geologist of Alabama, and to gain an insight into the works of reference for cretaceous and tertiary paleontology: of which not one had been provided by Harper, although at his request the costly illustrated works of Goldfuss, d'Ordigny and others, treating of European paleontology, had been placed in the University library. As these works did not furnish us with the means of identifying the fossils of the Mississippi formations, Harper seriously proposed to confer on them all, names of our own making, irrespective of previous observers. Upon my suggestion that this was rather an unusual mode of proceeding and might at the very least give rise to some confusion, he agreed that I might try to obtain from Tuomey the necessary information as to the possibility of procuring the existing American works, of which he, however, expressed a very low opinion. Hence my excursion to Tuskaloosa, in which I reaped the benefit of Tuomey's previous labors, and came to an understanding with him in respect to the subdivisions of the cretaceous, recognized by him. It happened that he had just returned from an excursion to the (Ripley) cretaceous area of Chunnenugga Ridge, which was entirely new to him, and the relations of which to the other groups he had not yet made out. Recognizing the characteristic fossils and marlstones of the Ripley group, I was enabled to clear up that point as well as the relations of the "Tombigby Sand" fossils (which had been sent to him from Columbus by Dr. Spillman) to the "Rotten Limestone," which we had thus far designated as "Upper," but agreed henceforth to consider as middle cretaceous. I then learned for the first time that he had found fossils,—well preserved ammonites and several gasteropods, silicified, in the lower cretaceous clays near Eutaw (or rather Finch's Ferry), Alabama; and we agreed to designate this lower clayey stage, which in Mississippi I had found entirely barren of fossils, as the "Eutaw" group. Subsequently, prior publication gave precedence to Safford's name of "Coffee group" for the lower clays, and similarly my "Tippah group" received from Conrad the prior name of "Ripley" for the uppermost cretaceous. Tuomey had at that time a portion of his second report in manuscript; and as unfortunately he died six months after our conference, after a protracted illness, that report, which was posthumously edited by J. W. Mallet, does not show the latest phase of Tuomey's knowledge of the cretaceous stages. As his collections were mostly destroyed during the war, it is of interest to record here, from my personal observation, that almost all the cretaceous fossils marked "Miss." in list "A." p. 257, of that report, were from the "Tombigby Sand" and the immediately overlying portion of the "Rotten Limestone." in Lowndes county, Miss.; the "Ammonites Binodosus," recorded in the same list, from Eutaw, Ala., was considered by him as a "leading fossil" of the lower cretaceous clays; the specimens were all silicified and in excellent preservation.

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*A collection of fossils from these beds was sent to Conrad by Dr. Spillman, of Columbus, to whom I had given a list of good fossiliferous localities of that group, of which he promptly availed himself. The same season (1856) in Conrad's published description of these fossils (Jour. Acad. Sci., Philadelphia, Vol. IV, N. S., pp. 275 to 291.) Dr. Spillman is erroneously credited with being the discoverer of the Ripley beds. My original collection, containing a number of species still undescribed, was unfortunately never seen by Conrad, with whom I twice made arrangements for a protracted visit to Oxford for the purpose of studying the collections of the survey. His feeble health and subsequent death prevented the carrying-out of this program.

†No instrumental topographical work was ever done in connection with the Mississippi survey, partly because it was not provided for by law, partly because the continually recurring violent barometric changes during the working season rendered the use of the aneroid; so useful elsewhere, very unsatisfactory. The railroad levelings then available were, however, fully and extensively used by me, and were excluded from the report of 1860, simply by the absolute need of brevity for the sake of reducing the expense of publication.

As regards the tertiary formations, Tuomey was strongly impressed with the fact that the older stages reappear above the drainage level to the southward, after sinking out of view at the St. Stephens bluff; and he suggested to me then that what I subsequently named the "Grand Gulf rocks" might be equivalents of the "Burstone" sandstones of South Carolina. So far as this point is concerned I was therefore strongly impressed with the same ideas that have been so persistently set forth by Otto Meyer. Having obtained from Tuomey references to all publications then extant on the cretaceous and tertiary of the south and west, I returned to Oxford in November, across a country rendered almost impassable by copious rains.

I found matters rapidly coming to a crisis at the University. Harper had been provided with a separate ambulance outfit, and had taken the field for a few weeks during the season of 1856 in the northwestern counties; but he seemed to be unable to keep away from Oxford for any length of time. Finally, the dissatisfaction of the board of trustees with his personal acts, in relation both to the survey and to the University, came to a head in November, 1856, when he was forced to resign. I was continued as assistant, with compensation increased to $1,500 per annum, and was for the time being placed in charge of the survey, the office work of which I continued during the winter.

At the legislative session of 1856-'7, however, Harper, by strenuous effort, procured the passage of an act entitled "An Act to provide for the printing of the Second Annual Report of the Agricultural and Geological Survey of the State, and for other purposes," approved January 31, 1857. The substantial provisions of this act were, first, the complete separation of the survey from all connection with the State University; second, that the survey should be prosecuted to completion according to the provisions of the previous act, "by a state geologist, to be appointed by the governor, and to receive a salary of two thousand dollars per annum, to be furnished with such an outfit as may be necessary, to be provided under the direction of the governor; he shall also keep an exact account of his expenses in making said survey, and submit the same to the examination of the governor, who shall issue his requisition upon the treasury for the amount, provided the sum shall not exceed one thousand dollars per annum." An appropriation of twelve hundred dollars was also made for the purchase of chemical apparatus for making analyses, and the state geologist was authorized (as a measure of economy suggested by himself), to "occupy as a laboratory the two front rooms in the second story of the penitentiary building; and he shall be allowed the assistance of one convict, to be named by the inspectors, to aid him in keeping his apparatus in good order." It was also ordered "that five thousand copies of Professor Harper's report be printed." and thereafter distributed in accordance with the provisions of the former act. The sum of thirty-five hundred dollars was appropriated for this publication, and Harper entered upon the office on March 1, 1857, but was voted compensation from the date of his resignation, in November preceding. The only work performed by him during his tenure of office under this act, was the writing and publication of his report, which was done under his personal supervision at New York, although, like the former report, it bears the imprint of the state printer at Jackson.

Of this report it need only be said that it is a literary, linguistic and scientific curiosity, and probably unique in official publications of its kind. It is the labored attempt of a sciolist to show erudition, and to compass the impossible feat of interpreting and discussing intelligently a considerable mass of observations mostly recorded by another working on a totally different plan from himself. In making use of my field notes, which of course passed into his hands, the facts as well as the conclusions suffered such distortion that but for the introduction of all the figures and diagrams given in my manuscript, I sould have been unable in many cases to recognize my own work. It is thus that the "Orange Sand" becomes in his hands "The Miocene Formation;" while what he saw of the Port Hudson beds, as well as the quarternary gravels, are referred to the eocene. Shortly after the publication of the book, I publicly disclaimed all responsibility for either facts or conclusions pretended to be based upon my work, since, although my name is nowhere mentioned in the volume, the innumerable errors would, in the course of time, be likely to be laid at my door. The circulation of the report through the state soon produced the inevitable result of discrediting its author to such extent that toward the end of the year 1857 he was obliged to resign his office.

Shortly afterwards the appointment was tendered to me (then acting as chemist to the Smithsonian Institution), and accepted; and I entered upon its duties early in 1858. At Jackson I found in the "two front rooms in the second story of the penitentiary," under the charge of the convict assistant, the outcome of the purchases made by Harper under the provision for the outfitting of an analytical laboratory. It consisted essentially of apparatus for elementary lectures in chemistry, and an expensive microscope: the analytical balance was represented by a pair of apothecary's scales, etc. Under authority of the governor, a portion of the useless articles were sold, and the proceeds applied to the purchase of necessaries for analytical work, and under the same authority and by permission of the Board of Trustees of the State University, I transferred the whole to a front room in the University building at Oxford, which I fitted up as a laboratory, at a personal expense of $600, for the time being. By this evasion of the law, framed under Harper's auspices (which was mandatory only in respect to the location of the "office," but not of the laboratory), the survey was again practically restored to its original connection with the University, without which the work could not be successfully carried on under so small an appropriation.

I took the field again in April, with the same outfit, an ambulance with two mules and a negro driver, and starting at the Ripley cretaceous, I devoted the season to the verification of a full section across the tertiary area, from north to south; including also the detailed examination of the fossiliferous localities of the "Jackson" and "Vicksburg" stages in their most characteristic development. Contrary to my first impressions, I found the Vicksburg beds everywhere along their southern limit of outcrops, dipping southward *under* the liguito-gypseous and sandstone strata of the "Grand Gulf" group, which rise abruptly and sometimes in steep escarpments from the low rolling or prairie country of the Vicksburg area; and being thus led to consider the Grand Gulf rocks as belonging to a miocene or possibly pleiocene epoch, I devoted considerable time to the study of its features and to the search for fossils. That this search was unavailing so far as the finding of definite animal forms is concerned, and that a subsequent continuation of the search over the rest of its area in Mississippi and Louisiana has led to no better results, I have stated and discussed in later publications.*

The fundamental fact of the infra-position of the Vicksburg beds to those of the Grand Gulf group that has been called in question by Otto Meyer, can easily be verified by any one understanding the logic of stratigraphical and hypsometrical facts in numerous localities along the belt of contact. I mention especially the outcrops at Mississippi Springs on Pearl river below Byram; on Richland creek, Rankin county; on the Brandon and Byram road; north of Raleigh, Smith county, and at numerous other points, both in Mississippi and Louisiana. No other interpretation of the stratigraphical facts is possible in a region where disturbances (apart from small local faults), are unknown, and where the broad facts are identical from the Chickasawhay to the Sabine.

In passing through the state I became painfully conscious of the fact that the survey had become extremely unpopular, as a consequence of Harper's incumbency and report; so much so that it was often very difficult to obtain information, or even civil answers to inquiries. I felt that it would be neces-

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*See my *Mississippi Report of* 1860, p. 147. *Am. Jour. Sci.*, 1887; *Ibid.*, Nov., 1869; *Ibid.*, Dec., 1871; *Ibid.*, July, 1881; also *Smith. Contr. Sci. Memoir, No.* 248.

sary to throw off, and purge myself completely, of the obnoxious antecedents, if the survey appropriation was to be sustained at the coming session of the legislature. I therefore, after consulting with Governor McWillie, wrote a short *Report upon the Condition of the Geological and Agricultural Survey of the State of Mississippi*, of 22 pages, 8vo., which was printed by executive order and circulated prior to the session of the legislature in the winter of 1858-'9. In this report I discussed, first, the need and advantages of a thorough geological and agricultural survey of the state; recited the causes of the slow progress and failure to satisfy the public, chief among which were inadequate appropriations and the incompetency of the late incumbent; also gave examples of what had been done in the matter in other states, and closed with a recommendation for the repeal of the law locating the headquarters of the survey in the state penitentiary, and for the restoration of the geological assistantship, in connection with a more reasonably adequate appropriation.

The storm, however, broke loose when the legislature assembled. Those who had been instrumental in passing Harper's bill in 1857, were now most eager to have the survey "wiped out" to allay their soreness. A special committee was appointed to investigate the subject, and without even giving me a hearing, that committee promptly reported a "bill to abolish the geological and agricultural survey of the state." In presenting this report the chairman inveighed fiercely against the insolence exhibited in my report, above alluded to, and my attempt to "coerce the legislature by forestalling public opinion." The report to abolish would undoubtedly have been promptly adopted, but for my forcing a personal conference with the chairman; in which I presented to him the documents in the case, and exhorted him to abolish *me*, if he thought there was cause, but not the *survey*, the revival of which would only be a question of time. After this, the "bill to abolish" was not called up, and the survey remained in *statu quo* during 1859.

The previous season's work having settled conclusively the succession of the several stages of the tertiary, and their prominent stratigraphical, lithological and paleontological features, I devoted the season of 1859 to the filling-in of details. I went more leisurely over the ground intended to have been covered by the previous joint expedition of Harper and myself in 1855, viz: from the southern border of the cretaceous area, near Columbus, down the Chickasawhay and Pascagoula valleys to the sea coast; along the coast to Pearl river, up that river to Columbia, Marion county, and thence across to the Mississippi; thence northward along the eastern border of the loess region to the belt of marine tertiary, which I also examined more in detail between Jackson and Vicksburg. All these observations only served to confirm and complete my previous conclusions; the only new point being the examination of the perplexing aspects under which the "Port Hudson group" (then provisionally designated by me as "Coast Pliocene"), appears on the shores of Mississippi Sound. I was not long in rejecting all ideas of its direct connection with the Grand Gulf strata; but its true character of a littoral member of the deposits of the loess epoch did not become apparent to me until, later on, I had the opportunity of studying, connectedly, the geology of southern Louisiana.*

Returning from the field somewhat earlier than usual I began the arrangement of materials for a report, to be presented at the legislative session of 1859-'60, with a view to its publication and the procurement of a better endowment for the survey.

As an earnest of the work done, I put up a collection of soils and marls, gathered during the three years' work, and had it on exhibition at the State Fair held at Jackson in November. It excited a good deal of attention and newspaper comment, and gave a favorable turn to public opinion, previously aroused by frequent communications of results made by me to agricultural and other papers of the state. Outside of the fair week I carried on the work of analysis and writing, simultaneously and unremittingly; the only assistance received being that of the legislature convened in December, 1859. But there was cataloguing of the tertiary fossils by Prof. W. D. Moore, then holding the chair of English literature at the University of Mississippi. The manuscript was not nearly completed when enough to satisfy a special committee that it should be printed, and that the working facilities should be enlarged.

The bill reported by that committee and afterwards passed with little difficulty by the legislature, makes no radical changes

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*See *Smith's Contra. Sci., Memoir No.* 248, above referred to.

in the previous act defining the objects of the survey; but provides for the appointment of an assistant geologist at a salary of $1,500; enlarging the limits of the annual "expenses necessarily incurred in fitting up a chemical laboratory," and repealing the provision for keeping an office at Jackson; permitting the alternative of having it at Oxford. An appropriation of three thousand five hundred dollars is made for printing the report, "with such diagrams and maps as the governor shall deem necessary for its illustration; and it is hereby especially enjoined upon his excellency, in the publication of said book, to have the same performed at the South, if the same can be done at an advance of ten per cent. upon the cost of its publication at the North."

The latter clause was a charactertistic sign of the times. The act was approved by the governor, February 10, 1860. It was soon and easily ascertained that the five thousand copies of the volume could not be printed anywhere at the South at an advance of ten per cent. on New York prices; but Governor Pettus declared that he would not allow it to go North under any circumstances, even if it had to remain unprinted. Estimates prepared by Mr. E. Barksdale, the state printer, showed that to do the work in his office would cost over $4,000, at the lowest estimate I placed upon the uncompleted manuscript. Finally, Mr. Barksdale proposed that if I should be personally responsible for $250 of the excess of cost over the amount allowed by the state, he would cover the rest; and I accepted the proposition. The governor relented so far as to allow the map which could not be furnished by any Southern establishment, to be prepared by the Coltons, at New York; the other plates were prepared at New Orleans. The printing was begun at Jackson in May, 1860; the latter parts of the report were largely written while the first portions were passing through the press. But several forms were not yet in print when in August imperative matters called me to Europe, and Prof. W. D. Moore, who had previously aided me in working up the lists of fossils, undertook to see the remainder of the work through the press. Hence there remain in the latter part of the book a number of uncorrected errata, of which none, however, are of material consequence.

In this report, which except as otherwise credited in the text, represents my personal field, office and laboratory work during four years). I undertook to separate as far as possible. the purely scientific part from that bearing directly upon practical points, in order to render the latter acessible to unscientific readers as the nature of the case permitted; while at the same time giving scientific discussion full swing in its proper place. This was the more necessary, as my predecessor's reports had been sharply criticised in this respect; and I think the result has justified my judgment in the premises. The volume is thus divided nearly evenly between a "geological" and "agricultural" portion; the former giving under the special heading of "useful materials" the technically important features of each formation, after its geological characters have been discussed. In the agricultural portion, it seemed needful at the time to give, by way of introduction, a brief discussion of the principles of agricultural chemistry, then but little understood by the general public; and, accordingly, fifty pages are given to this subject and are discussed with reference to the agricultural practice of the State. In the special or descriptive portion of the agricultural report, the State is divided into "regions" characterized by more or less uniformity of soil and surface features; and each is considered in detail with respect to all natural features bearing on agricultural pursuits; special attention being given to the nature of the soils, as shown by their vegetation and analysis. In the latter respect I departed pointedly from the then prevailing opinions, by which soil analysis was held to be practically useless. My exploration of the State had shown me such intimate connection between the natural vegetation and the varying chemical nature of the underlying strata that have contributed to soil formation, as to greatly encourage the belief that definite results could be eliminated from the discussion of a considerable number of analyses, of soils carefully observed and classified with respect both to their origin and their natural vegetation, and a comparison of these data with the results of cultivation; and that thus it would become possible, after all, to do what Liebig originally expected could be done, viz: to predict measurably the behavior of soils in cultivation from their chemical composition. To what extent this expectation has been fulfilled, is hardly apparent from the very limited number of analyses which my unaided work [illegible] in the same line [illegible] much adverse criticism, which [illegible] afterwards. [illegible] that the [illegible] the natural [illegible] of virgin soils [illegible] of the limitations imposed by [illegible] and by previous treatment [illegible]*

[illegible] the importance of agr- [illegible] generally [illegible] sufficiently [illegible] investigations [illegible] specially [illegible] and mineral resources of the [illegible] classification of lands" provided for [illegible] United States Geological Survey [illegible] more pressing significance. Even apart [illegible] of soil composition, the right [illegible] at least a good, intelligent [illegible] the surface features of a region [illegible] agricultural capabilities and its adapt- [illegible] be tested. With the addition [illegible] the intelligent application of soil investi- [illegible] region, sometimes almost [illegible] branch of the public surveys has thus [illegible] charged with their execution [illegible] among the older American geol- [illegible] kept the agricultural interests [illegible] prominence in his researches and re- [illegible] personal intercourse with him predisposed [illegible] in this respect, my further experience [illegible] my conviction that a reasonable [illegible] agricultural work would effect- [illegible] our state surveys, whose fate is for- [illegible] at each reassembling of the legis- [illegible] their continued endowment depends. [illegible] their utility is constantly called in question. No such question was raised in Mississippi after the publication of my report of 1860; and the legislative appropriations for substantially similar work done by me on behalf of agriculture have since been liberally maintained in California, despite the conspicuous disfavor with which the geological survey of that state has for many years past been regarded by the public. Had that survey been adapted to the legitimate needs of the state, by proper diligence in the pursuit of its agricultural side, the discontinuance of the work could never have been carried through the legislature.

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* [illegible] and discussion of the nature and [illegible] Report on Cotton Production in the United [illegible] Reports of the 10th Census; also Am. Jour. Sci. [illegible]

As a striking exemplification of the change wrought in public sentiment by the energetic prosecution of agricultural survey work, I may quote the action taken at the called session of the legislature of Missisipi in August, 1861. Under the terrible stress brought to bear on the state even then by the impending conflict, it would have been natural to expect the complete extinction of the appropriation for the survey work. Instead of this, an act was passed suspending the appropriation for the geological survey "until the close of the war, and for twelve months thereafter; except the sum of $1,250 per annum, which shall be applied to the payment of the salary of the state geologist, and the purchase of such chemicals as may be necessary to carry on the analysis of soils, minerals and mineral waters and to enable him to preserve the apparatus, analyses and other property of the state connected with said survey." This appropriation was actually maintained during the entire struggle of the confederacy; and so far as the vicissitudes of war permitted, the chemical work (and even some field work) was continued by me during the same time. The scarcity of salt suggested a utilization of some of the saline waters and efflorescences so common in the southern part of the state, and some forty (unpublished) analyses of such saline mixtures are on record. I made an official report on the subject to Governor Pettus, dated June 9, 1862. I also made a special exploration on the several limestone caves of the state, with a view to the discovery of nitrous earths; but from the fact that these caves are all traversed by lively streams, I found nowhere a sufficient accumulation of nitrates to render exploration useful.

Soon after the beginning of active hostilities in Tennessee, the University faculty having been dissolved, I was detailed by [illegible] governor as commander of the state militia, to take charge of the state property at the University during the war; and this, as well as a government appointment by the confederate government as an agent of the "Nitre Bureau," prevented my being called into active service, except on the occasion of the siege of Vicksburg, when, toward the end of that memorable siege, I was ordered to erect "calcium lights" on the bluffs above the city for the illumination of the Federal gunboats when attempting to run the gauntlet of the batteries. The difficulties of construction and procuring of the necessary materials [illegible] the completion of the arrangements, so that at the occasion of the final passage of the fleet no adequate light could be given. From a hospital at Jackson, where I was a patient at the time of my first capture, I soon afterwards made my way to my post at [illegible], where I remained on duty during the rest of the war. This post was sometimes a very arduous one, [illegible] being then within the "belt of desolation" between the two armies which swept back and forth over it. The survey collections had several very narrow escapes from destruction when the buildings were hastily occupied for hospital purposes; they were several times transferred to hospital [illegible] one building to another, but finally escaped without any material injury [illegible] the collections at the capitol at Jackson, where the [illegible] cases seem to have been swept and [illegible] the floor was strewn with broken specimens [illegible] glass [illegible] about one-third of the collection [illegible] was entirely ruined, and of the remainder [illegible]

[illegible] November 1865, I [illegible] afterwards I was shipped to St. [illegible] The political events which soon afterward [illegible] prevented the return of the bound copies [illegible] remained warehoused in the binder's [illegible] war between the states, and it was not [illegible] were taken out for delivery. The war [illegible] having acquired the survey [illegible] the basis of the act of 1860, and I [illegible] E. Barksdale [illegible] the agreement in respect to the [illegible] my obligation to contribute $250 toward the payment of its cost, which under the conditions then existing was a heavy tax. The edition was received at Jackson early in 1866, and thence distributed according to law.

The mule team of the survey had been sold by authority from the governor, soon after the passage of the act of suspension. There being no legal mode of turning the proceeds into the state treasury, they remained in my custody in the form of "Cotton Money" (notes issued by the state upon "cotton pledged" for their redemption) during the war; and as at its end these notes had become worthless, the survey was left without means for repurchase. Subsequently, however, a suitable team was procured out of the appropriations for current expenditures.

Dr. George Little, formerly professor of natural sciences at Oakland College, near Rodney, Miss., was appointed assistant geologist in July, 1866, and shortly thereafter took the field for detailed exploration of the loess region from Rodney to its fartherest point in Louisiana; the special object being to ascertain its relation to the "Coast Pliocene" or Port Hudson beds on the one hand, and to the southern equivalent of the "Yellow Loam" of Mississippi and Tennessee on the other. The general results of this exploration are briefly stated in Memoir No. 248 of the Smithsonian Contributions, p. 4, viz: That the loess material gradually changes toward that of a non-calcareous and non-fossiliferous hardpan or indurated loam, from a point about eight miles below the Louisiana line, and seems also to thin out. No detailed report of field notes of this trip are on record.

In view of the difficulties and insecurity besetting the office of state geologist under the *regime* then existing in the state of Mississippi, in October, 1866, I accepted permanently the chair of chemistry at the University; and Dr. Little was then, upon my recommendation, appointed state geologist. He took the field in autumn of 1867, in order to re-explore the section of the tertiary strata afforded by the Chickasawhay river, between Enterprise and Winchester. He descended the stream in a canoe, making numerous portages over shallow stretches. The result of this re-examination was simply a confirmation of the observations previously made by myself, going by land, in 1859. Of this exploration, also, no detailed record or report is on file.

No field work was done by Dr. Little in 1868, partly because by consent of the governor he was acting as professor of geology and mineralogy at the University in addition to the survey work in the laboratory and collection rooms. In October, 1870, however, he definitely resigned the state geologistship for the professorship of geology and natural history in the University, and in order to prevent the survey from being either abolished or falling into the wrong hands, I again assumed its direction without additional compensation; it being understood that I should be under no obligation to take the field personally. In November, 1868, the assistantship had been most fortunately filled by the appointment of Dr. Eugene A. Smith, of Alabama, then just returned from his studies in Europe. Dr. Smith took hold of the work with his characteristic energy, although the first work in order was not of the most interesting character: namely, the farther prosecution of the analyses of soils and marls selected so as to cover as nearly as possible all parts of the state. This work was carried on by him through the year 1869 and a portion of 1870. In September of that year he took the field, with the usual outfit of a two-mule ambulance and driver. There were then two regions in the state that had not been at all satisfactorily explored: one the belt northward of the Jackson area, of which only the portions lying in Neshoba and Lauderdale counties on the eastern border of the state, and a small area in Attala county, near the Central railroad, had been somewhat minutely examined by me. This being the connecting link between the "northern lignitic" and calcareous marine stages, its examination was of special interest, but at the same time a difficult task on account of the extreme variability of its materials and fossils, and the scarcity of outcrops. The other comparatively unknown region was the great "Yazoo bottom," the geological exploration of which had become of especial interest in connection with the question of the age of the formation of the gulf coast and delta.

While the Bottom region was to be the chief objective point of the first expedition, Dr. Smith availed himself of the opportunity of observing a section across the older tertiary in passing from Oxford to Yazoo City via the Pontotoc, "Flatwoods," Kosciusko and Jackson.

He then descended into the Yazoo bottom and traversed it, zigzagging from the river to the bluff from near Vicksburg to its head near Memphis. In this laborious and insalubrious trip he studied carefully both the surface features of the great alluvial plain, and the geological features of the deposits that form its substrata. A summary report of this important exploration was given by him at the Indianapolis meeting of the A. A. A. S., and was published in the volume of *Proceedings* of 1871, p. 252. The outcome of these observations is there summarily stated to have been that "the true river deposits, of any considerable thickness, are mostly confined to narrow strips of land lying on both sides of the Mississippi and of the bayous and creeks, and to ancient channels since filled up; while a large proportion of the superficial area of the bottom, including some of the most fertile lands, is derived from the clays of older formations into which these beds have been excavated." The equivalence of this older clay formation with that of the Port Hudson profile, already suggested by me, was thus fully verified.

Returning to Oxford early in December, Dr. Smith carried on the chemical work until the end of May, 1871, when he took the field again in order to trace across the state the "Siliceous Claiborne" belt, referred to. His route lay from Leake county southeastward to the Alabama line, along the northern contact of the problematic "Red Hills" and yellow sandstones with the lignitic formation; then westward again in the more southerly portion of the belt, to the border of the Yazoo bottom (the "Mississippi bluff"). In this trip he traced the connection and established the equivalence of the ferruginous formation as a local feature, with the sandstones of Neshoba and Newton counties; which connect unequivocally with the characteristic "buhrstones" of Lauderdale.* The beds of the Jackson group were then traced by him, down the edge of the bluff to Yazoo City and Vicksburg, forming the third complete section across the eocene observed in Mississippi.

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*The more extended development of the ferruginous feature in northern Louisiana was afterwards observed and described by myself. (Am. Jour. Sci., Nov., 1868, p. [illegible]; *Supplementary and final report of a geological reconnoissance of Louisiana*, p. [illegible]. Also Rep. on the cotton production and agricultural features of Louisiana, in *Report of the 10th Census U. S.*, Vol. 5, pp. [illegible].

In September, 1871, Dr. Smith resigned the assistantship to take the chair of geology and mineralogy in the University of Alabama, with which, through his efforts, the state geologistship of that state was afterward connected.

His successor in the assistantship of the Mississippi survey was Mr. R. H. Loughridge,* of Texas, who had for some time previously acted as my assistant in the chemical laboratory, and subsequently as instructor in general chemistry. Mr. Loughridge prosecuted the chemical work of the survey during a part of the year 1872, and was preparing for the elaboration of another report covering the work done since the publication of the report of 1860: when by an arbitrary ruling of the state auditor of public accounts the survey appropriation was withheld; and thus in the autumn of 1872 the work was peremptorily stopped.

It has not been revived since, although so far as I am aware the act of 1860 has never been legally rescinded. No provision for the publication of the unpublished results has ever been made by the state; the records and collections of the survey remain in the custody of the University of Mississippi, and were left by me fully labeled as to locality and time of collection, with reference to the field notes, and to the name or designation under which the specimens of fossils appeared in my report of 1860.

When I took charge of the Tenth Census report on cotton production, and at my suggestion it was determined by Superintendent Walker that agricultural descriptions of the cotton states should be embodied in the report, I requested of President A. P. Stewart, of the University of Mississippi, permission to use the records of the survey in the elaboration of the report on that state. Permission was promptly given and the papers forwarded to Berkeley, Calif.; and they were used by me as intended, in the composition of the monograph on the agricultural features and cotton production of Mississippi, which forms part of Volume 5 of the Census Reports for 1880. This paper embraces 1[illegible]4 quarto pages, and is accompanied by a colored map of the state; showing the several soil regions, which in this case largely coincide with the geological subdivisions as given on the map accompanying the report of 1860. While the surface features of the state are given very much in detail, the geological description is considerably condensed, into one and a quarter pages; since greater minuteness of description would have lain outside of the objects of the report. Hence, except as casually mentioned in connection with the surfaces, the geological observations made by Dr. Smith in 1870 and 1871 remain unpublished, save as regards the abstract of his observations in the Yazoo bottom, given in the paper referred to before.

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*Mr. [illegible] from the University of Mississippi [illegible] several years as assistant to Dr. Little [illegible] Subsequently, acting under my direction [illegible] he made a reconnoissance of Texas, and [illegible] State, Arkansas, Indian Territory, Georgia and Mississippi [illegible] tion. Later he served on the [illegible] and is now connected with the [illegible]

A revised edition of the report of 1860 would, without additional field work, form a pretty complete account of the geological and agricultural features of the state.

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2. *Preliminary report on the Geology and Agriculture of the State of Mississippi,* by L. Harper, LL. D., State Geologist of Mississippi. By order of the Legislature of Mississippi. E. Barksdale, State Printer, Jackson, 1857. 362 pp., 8 vo., with map, 52 figures in the text and seven special maps and plate.

3. *Report on the Geological and Agricultural Survey of the State of Mississippi,* by Eugene W. Hilgard, State Geologist, Jackson, Mississippi. Steam Power Press Print. 1858. 22 pp., 8 vo. (printed by order of the Governor).

4. *Report on the Geology and Agriculture of the State of Mississippi,* by Eugene W. Hilgard, Ph. D., State Geologist, printed by order of the Legislature. E. Barksdale, State Printer, Jackson, Mississippi, 1860. 417 pp., 8 vo., map, two plates of geological sections and 5 diagrams printed in the text.

5. *Report to Governor John J. Pettus, on the Resources of the State of Mississippi for the Manufacture of Salt.* About 4 pp. octavo, but published only in the newspapers of the State at the time. Dated Oxford, June 9, 1862.

6. Circular Announcing the Resumption of the Geological and Agricultural Survey of Mississippi, after the Cessation of the War. About 4 pp. 8 vo. Sent in two column open sheets to the officials and newspaper press of the State. Dated Oxford, July, 1866.

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2. Remarks on the New Division of the Eocene, or Shell Bluff Group. Proposed by Mr. Conrad. *Am. Jour. Sci.*, July 1866. 4 pp.

3. Remarks on the Drift of the Western and Southern States, and its Relation to the Glacier and Iceberg Theories. *Am. Jour. Sci.*, Nov., 5 pp.

4. On the Tertiary Formations of Mississippi and Alabama. *Am. Jour. Sci.*, Jan., 1867. 12 pp.

5. On the Geology of Lower Louisiana and the Rock Salt Deposit of Petite Anse Island. *Am. Sci. Jour.*, Jan., 6 pp.

6. Preliminary Report to the New Orleans Academy of Sciences, of a Geological Reconnoissance of Louisiana. *De Bow's Review*, Sept., 1869. 15 pp.

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8. Report on the Geological Age of the Mississippi Delta. *Rep. U. S. Eng. Dept. for 1870.* [illegible] pp.

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17. [illegible] F. V. Hopkins) on the borings [illegible] Vicksburg, by the Miss. [illegible] 1883. p. 479. 18 pp.

18. Report on the Cotton production and Agricultural Features of the State of Mississippi, 4to, 164 pp. with two maps. In Volume 5 of *Reports of the Tenth Census.*

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20. The Salines of Louisiana, *U. S. Geol. Survey Report on the Mineral Resources of the United States*, 1883, p. 938. 8 pp.

21. The Old Tertiary of the Southwest. *Am. Jour Sci.*, October, 1885, 4 pp.

22. Orange Sand, Lagrange and Appomattox. *Am. Geologist*, Vol 8, 1891, 2 pp.

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EDITORIAL COMMENT.

PLEISTOCENE GEOLOGY OF NORTHERN AND CENTRAL ASIA.

Prof. George Frederick Wright, of Oberlin, Ohio, and his son, Fred B. Wright, returned home about April 1st from a journey around the world, chiefly for geological observation, which occupied somewhat more than a year. Their route was by the Southern Pacific railway to California, thence to Hawaii, Japan, and China, leaving the [illegible] beginning of the Boxer massacres [illegible] ed much delay and peril, by the Siberian [illegible] Baikal, and traveling the vast Russian [illegible] burg; thence through the region [illegible] Black and Caspian seas, [illegible] the Mediterranean and [illegible] thence by [illegible] and New [illegible] given [illegible] presence [illegible] March [illegible] at a meeting [illegible] presented a paper on [illegible] and Central Asia [illegible] servations are summarized [illegible] in the Proceedings of that [illegible]

"The [illegible] there are [illegible]

Neither is there any sign of glaciation along the border of the Mongolian plateau, where the general elevation is 5,000 ft. but the whole region is covered with loess. This has usually accumulated like immense snow-drifts on the southeastern, or lee side of the mountains, and in it houses and villages are excavated. In the mountainous region, strata of gravel and pebbles are so frequent in the loess that it is necessary to invoke both wind and water in order to explain fully the origin of the deposit. At the present time the loess in the interior is being washed away by the streams much faster than it is being deposited by the wind. The journey across Manchuria from Port Arthur along the Loo-Ho and Sungari rivers was through valleys choked with alluvium, and there was no evidence that the drainage of the Amur had ever been reversed by ice, like that of the St. Lawrence; nor was there any other evidence of glaciation. The lower course of the Amur indicates subsidence. Again, there are no signs of glaciation on the Vitim plateau.

"Lake Baikal appears to be of recent origin; it is 4,500 feet deep, and has not been filled by the great quantities of sediment brought down by the Selenga and other rivers. Although glaciers could frequently be seen on the mountains which border the Central Asiatic plateau on the northwest, there was no evidence that the glaciers had ever deployed on the plain. The loess region of Turkestan, and indeed the whole area from the sea of Aral to the Black sea, appears to have been recently elevated, in some places as much as 3,000 feet. Desiccation took place at the same time, so that the larger lakes are only brackish or still fresh. Direct evidence of this in the form of deposits is given. The author thinks it likely that the absence of glaciation in northern Asia may have been due to the rainlessness of the region, and that, while America was elevated, Asia was depressed during the Glacial epoch."

In connection with the discussion of this paper, Prof. Wright disclaimed any intention to imply an eolian origin for the loess of the Mississippi valley, but attributed its deposition there to annual river floods mostly of short duration, followed generally during a greater part of each year by aerial exposure of the flood plains, permitting it to be occupied by vegetation and land snails. W. U.

REVIEW OF RECENT GEOLOGICAL LITERATURE.

Was Mount Royal an Active Volcano? By J. S. [illegible] C. L. Canadian Record of Science, Vol. VIII, No. 5, pp. [illegible]

It is well known that the broad and nearly level valley [illegible] Lawrence, which is underlain with paleozoic strata, has suffered [illegible]mous denudation, unique evidence of which is furnished by [illegible]ing series of intrusive hills which crosses the valley from M[illegible] Shefford. These, owing to their greater resistance [illegible] out in bold relief, rising to hights of seven hundred [illegible] feet above the plain, while high up on their slopes, [illegible]ments are often found *in situ*, giving unmistakable [illegible] once greater thickness of the sedimentary depo[illegible]

In the above mentioned paper, these and other [illegible]cussed in support of the hypothesis that Mount [illegible]ered laccolite instead of a once active volcano [illegible] seven hundred and forty-four feet above the [illegible] Montreal and sedimentary patches occur [illegible] corroborative evidence the plutonic character [illegible] together with the absence of tuff or eff[illegible] as a slight uplift of the strata in [illegible]

Since the absence of any but [illegible]ficiently accounted [illegible] and as the uplift [illegible] is probably [illegible] The generally [illegible]

[illegible]

perial Institute, London, and was pronounced by experts to be of exceptionally high value for electrical purposes. Molybdenite from Quebec and Ontario was tested in the laboratory of McGill university and samples of auriferous black sands from the Atlin district were also examined. These samples varied from 0.5 oz. gold per ton to 5.985 oz. gold per ton. Mention is made of the discovery of anthracite coal in the region about the headwaters of the Skeena and Slikine rivers. It is estimated there are 22,000,000,000 tons of possibly workable coal in the Crow's Nest Pass coal fields. Coal has also been found in the Klondike region but so far possesses only a medium economic value.

Reference is made to the collection sent to the Paris exposition. This collection weighed about 70 tons, and comprised over 1,200 separate exhibits and was much larger than any shown by Canada at any previous international exposition. The awards actually awarded to the Canadian mineral exhibits comprise six grand prizes, ten gold medals, eighteen silver medals, nine bronze medals and four honorable mentions.

The most important facts of economic value are contained in the descriptions of the following: The placer mines (estimated to produce over $10,000,000 this year), the lignite area and the White Horse copper deposits in the Yukon district, the Atlin and West Kootenay gold fields and the extensive coal area of the Crow's Nest pass, in British Columbia, the iron bearing rocks of the Michipicoten district including the Helen mine, which from definite measurements contains 20,000,000 tons of ore and possibly a much larger quantity; the alluvial gold deposits of New Brunswick, and the extensive and important coal deposits of Springhill and Cape Breton in Nova Scotia. A large amount of work was done by all the field parties in mapping out the geological formations, and in making surveys and collecting facts about the regions traversed so that the report contains valuable information about the physiography and natural history of large areas in the older provinces as well as in outlying districts including Great Bear lake.

The work done in chemistry and mineralogy, mineral statistics, petrography, palaeontology and zoology, botany and mapping is fully set forth by the gentlemen in charge of these branches. W. J. W.

Analysis of Emery from Virginia. By W. W. MILLER, JR. *Am. Chem. Jour.*, 22, 212-213.

The emery occurs in a heavy ledge near Whittle's on the line of the Southern railroad in Pittsylvania county. It is described as a black, crystalline mass, magnetic in character, with specific gravity 4.205; and hardness 8. The analysis shows—alumina, 50.74; ferric oxide, 15.50; ferrous oxide, [illegible]; silica, [illegible]; titanic oxide, 1.86; soda, 3.05. The ferrous oxide in excess of that required to form magnetite, is supposed to be present as hercynite ($FeAl_2O_4$) and the soda is considered to take the place of the ferrous oxide in forming additional hercynite, thus reducing the amount of alumina which can exist as corundum.

paratus of especially desirable pattern have been figured in the text. Chemists will find the parts devoted to the estimation of small quantities of the rarer rock-forming elements, titanium, zirconium, chromium, vanadium, molybdenum, barium, and strontium of particular interest; also those devoted to ferrous iron. The author finds in the strong reducing action which sulphides even in small amounts have on ferric salts, an explanation of the fact that ferrous iron estimations by the sealed tube method of Mitscherlick give higher results, as a rule, than those ontained by other methods, this difference becoming more marked as the percentage of iron increases. All rocks contain sulphur, at least in traces, and the more highly ferruginous ones not only commonly carry higher percentages of ferric iron, but considerable quantities of iron sulphides, conditions exactly calculated to produce the results obtained. During the heating of the rock powder with sulphuric acid in the sealed tube the sulphur of the sulphides is oxidized to sulphuric acid at the expense of the ferric iron. In this way as little as 0.10% of sulphur increases the ferrous iron by an error of 1.35%. This seems to furnish a correct and interesting explanation of a long unsolved problem. The wide experience and established reputation of the author make this carefully prepared bulletin a most valuable addition to the literature of analytical chemistry and it will find wide use by geologists and petrographers interested in rock analysis. W. O. C.

Analyses of Rocks. Laboratory of the U. S. Geological Survey. Tabulated by F. W. CLARK. (*Bull. No.* 168, *U. S. Geol. Sur.*)

In this bulletin are tabulated the results of 1,404 analyses of rocks, minerals, clays, etc., which have been made between the years 1880 and 1880, by the chemists connected with the U. S. Geological Survey. The analyses are arranged in groups according to the geographical location of their respective rocks, and with each one are such notes and references as are necessary for the proper identification and study of the rocks. A table, showing the average composition of the earth's crust as calculated by F. W. Clark from some eight hundred carefully selected rock analyses, is an interesting and valuable part of the introduction. Every geologist will appreciate the high value of this bulletin. W. O. C.

An Experimental Investigation into the Flow of Marble. BY FRANK DAWSON ADAMS and JOHN THOMAS NICHOLSON. (*Phil. Trans. Roy. Soc. London, Series A, Vol.* 195, pp 363-401, pls. 22-25. 1901.)

The artificial production of structures found in nature is a department of investigation capable of yielding data on many problems of a theoretical nature. The folding and flowage of rocks in the deeper part of the earth's crust are commonly supposed to be due to the interaction of three factors: great pressure, high temperature, and percolating water. In the experiments here described carrara marble is placed in specially constructed cylinders and subjected to differential pressure under varying conditions. Dry marble at ordinary temperatures developed a cataclastic structure, exhibiting an anastomosing network of calcite granules with marked shearing lines. Macroscopically

series, the whole had been folded in two directions and extensively faulted and eroded; and at some times before this, enormous masses of granite had been intruded, cutting the veins and folds. These granites are not all of the same age, but range from pre-Silurian, when some of it in the east probably cooled, to Devonian, which is the age of the large mass in the western half of the province, if it be one intrusion as seems likely. It is probable that the mountain building was pre-Silurian. Before lower Carboniferous times, three-fourths of the whole gold series had been eroded from some regions.

Dr. Daly has done well to emphasize the real lack of mountainous projections in this part of Nova Scotia. Transportation companies' prospectuses, with the too vivid descriptions of untrained travelers, have given a prevailing impression of ruggedness where none exists. For this there is excuse; but there is none for the statements on the subject which have appeared in some geological articles.

The structure and history of the Triassic area and the history of the Bay of Fundy trough are reviewed at length, from the literature. The main peneplain has been affected by two warps, one in the direction about S. 30° E., east of Digby; the second transverse to it, affecting the western part. These are believed to have aided in the formation of the Tertiary lowland on the Trias, by reviving subaërial work. The Carboniferous areas are referred to the same age as regards their denudation, from similarity of hight and topographic form. The dates of the two peneplains have been placed as Cretaceous and Tertiary, on account of similarity with corresponding ones along our own Atlantic coast. At the close of the paper, (p. 98), a table of homologous forms, expressed in terms of history is presented, comparing New England and Acadia; and the general resemblance is certainly striking.

Shore and stream development are not considered; but, especially with no topographic maps for the area, this would require a large amount of field work, and doubtless will be given to us in time. Cape Breton is entirely left out of the problem; and perhaps this is well, for it requires special study, being largely a topographic and geologic unit of itself. It may be said, however, that it has had a somewhat similar development in outline.

The gelatine plates are for the most part excellent, and give very vividly, especially to one who knows the structure of the country, some of the chief topographic phases. The map leaves something to be desired, in that it is too light; and it might better have occupied the whole page, the legend being placed on a separate sheet.

On the whole, any criticisms of this first study must be of a minor nature; and we owe much to Dr. Daly for being the first to give us an intelligent idea of the topographic development of a country hitherto rather neglected. The recent tendency of American students to invade Canada deserves a passing notice. Within a year, for instance, two more studies, of a quite detailed nature, will be published from Harvard University, dealing with problems which, from the nature of the work, have been largely overlooked by previous observers. J. E. W.

The Structural Relations of the Amygdaloidal Melaphyr in Brookline, Newton, and Brighton, Mass. BY H. T. BURR. (Bull. Mus. Comp. Zoöl., vol. xxxviii. Geol. Ser., vol. v., no. 2, pp. 53-69, 2 pls.)

In earlier years, the melaphyrs of the Boston basin have been considered as contemporaneous flows by some writers. The present paper appears to prove beyond doubt that those of the western portion, included in the above-mentioned territory, are entirely intrusive. We have no fossiliferous horizon to use as a key to structure; and the presence of contemporaneous flows would be welcome. Their proved absence in the western areas removes that aid, as far as those areas are concerned. Readers who are familiar with the geological literature of the region know the general relations of the rocks as regards position, and it is not necessary to state them here.

A word may not be out of place, concerning the methods used in this study, which was an incidental one; for they illustrate the careful approach which is now employed in the problems in this difficult field. A detailed outcrop map was plotted on a very large scale, made possible by the aid of city engineers. This gave the exact location of every exposure of melaphyr, and of the other rocks as well. Detailed observations were recorded for each outcrop, and specimens collected when necessary, for petrographic work. The result appears in the character of Mr. Burr's paper, which is a mass of clearly presented evidence, with the inevitable conclusions drawn from it. The former is so stated that the precise outcrops are indicated, and one can without difficulty prove the worth of the observations for himself. This is as it should be.

The evidence is of three kinds: lack of melaphyr pebbles in the overlying conglomerate, negative but confirmatory; character of the upper contacts of the melaphyr; and structural relations. The summary is worth giving in full. "(1) The melaphyr, in the region discussed, is intrusive in the sediments. (2) The melaphyr is not associated with any definite horizon, and is therefore of no value as a guide to the interpretation of the structure. The first conclusion depends upon the following facts: 1. The conglomerate, associated with the melaphyr, contains no fragments of it. 2. The contacts, wherever found, are igneous in character. 3. The melaphyr is seen in contact with sediments, varying from the coarsest of the conglomerates to the finest of slate. 4. The distribution of the melaphyr shows it to be discordant with the structure of the sediments under any interpretation of the latter that has been offered. The second conclusion follows directly upon the first."

While these problems occupy most of the paper, space is given to a new interpretation of the structure of the Chestnut Hill slates and the northern conglomerate, which harmonizes with the field evidence better than any of the earlier views. J. E. W.

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CORRESPONDENCE.

Are the Amygdaloidal Melaphyrs of the Boston Basin Intrusive or Contemporaneous?—The recent paper by my friend Henry T. Burr on the "Structural Relations of the Amygdaloidal Melaphyrs in Brookline, Newton and Brighton, Mass.,"[1] is, in the main, a criticism of my view that the melaphyrs of this area, as of the other parts of the Boston Basin, are chiefly contemporaneous, and of an unpublished map by Woodward in which that view is embodied. I have not claimed that the melaphyrs are wholly contemporaneous, recognizing that they must be intrusive at some points, since the magma necessarily reached the earth's surface before it could play the rôle of an effusive; but in the area which he has studied, Mr Burr finds all the melaphyrs to be intrusive. His argument rests largely upon the evidence of the contacts, which are found to be, without exception where clearly exposed, igneous. Details which appear to support this thesis are made the most of; but broad, fundamental facts which tell strongly against it have not been duly considered. No attempt is made to show that none of the irregular contacts supposed to be igneous could be as well explained as due to the covering by sediments of the cracked and scoriaceous surface of a submarine flow; or that the supposed baking of these overlying sediments is never silicification accompanying the chloritization of the melaphyr. The [illegible] with the contact is emphasized [illegible] this feature belongs also to the free surface [illegible] igneous contact with another [illegible] the title of his paper, as quoted [illegible] account of the very [illegible] textures of the [illegible] dikes of melaphyr [illegible] width. He starts [illegible] trap dikes of the district [illegible] distinguishable; but does [illegible] and the melaphyr are [illegible] like of the melaphyr [illegible] aphanitic [illegible] crystalline and homogeneous [illegible] are dikes from [illegible] interesting to know [illegible] a fissure 3,000 [illegible] in the crust per[illegible] vesicular textures [illegible] at the surface; but [illegible] of this effu[illegible] sive material. These supposed dikes are represented as transverse to the dip of the enclosing strata; but their close conformity with the strike of the sediments is not explained.

Another fundamental fact which is overlooked is the occurrence in this area, and in intimate association with the melaphyr, of important beds of melaphyr tuff. The genetic relations of the tuff to the melaphyr cannot be questioned; and the existence of the former should be regarded as conclusive as to the contemporaneous origin of a part at least of the latter. Much is made of the supposed absence of melaphyr pebbles in the overlying conglomerates. These are not, however, wholly wanting; and at some points they are a very striking and significant feature of the contact. For instance, between Newton Upper Falls and Newton Highlands, in the western part of Mr. Burr's field, a north-south section shows, if there be no repetition of the strata by strike faulting, four heavy beds of conglomerate and sandstone, all dipping in a general northerly direction at angles of twenty to forty degrees, separated by three broad bands of melaphyr. The most clearly exposed contact in this series is the uppermost, or that between the northern band of melaphyr and the overlying conglomerate. This melaphyr is, in the southern (lower) part of the band, a solid and homogeneous rock of approximately holocrystalline aspect; but northward it becomes more slaty, in part amygdaloidal, brecciated and scoriaceous; and at last is decidedly shaly in structure, looking more like a tuff than a flow. It is covered by the conglomerate with apparent conformity; and the conglomerate is, on and near the contact, not injected by the melaphyr, but crowded with angular fragments of precisely similar melaphyr. Within a yard above the contact the melaphyr detritus begins to die out; and at a distance of two yards an occasional fragment only is to be found. The melaphyr in the conglomerate is clearly a contact feature; and it can not be doubted that this body of melaphyr was in existence as a surface formation when the deposition of the conglomerate began. Everything goes to indicate that these effusive eruptions were submarine; and at Nantasket, as also in Brighton, we have conclusive proof, in the well preserved wavy and ropy surfaces of the flows, that in some instances they were covered without suffering erosion.

The main bodies of melaphyr, throughout the Boston basin, have all the characters of lava flows and are essentially unlike any known dikes or sills. In other words they are masses which fundamental and indisputable facts indicate to be contemporaneous. And yet, because of certain minor irregularities of contact and appearance of baking, etc., they are described as intrusive; and highly improbable sections, with transverse dikes thousands of feet wide, are constructed to explain their structural relations. Apparently every irregular or transverse contact is to be regarded as igneous, ignoring all the ragginess of a normal lava flow, to say nothing of subsequent faulting and crushing, and ignoring the almost inevitable induration by silicification, of a sediment in contact with such a prolific source of free silica as these basic lavas were during the process of [illegible], and certainly nothing is more normal than the impregnation of sediments in contact with a basic eruptive by ferruginous minerals, thus readily explaining through, or by subsequent oxidation, the very local reddening of the sediments extending commonly less than an inch from the contact, to which Mr. Burr attaches much importance. Of the excess of free silica during the alteration of the melaphyr we have substantial evidence in the quartz and jasper amygdules and segregations which often crowd the melaphyr and the numerous veinlets of quartz frequently to be observed in the immediately bordering sediments.

Mr. Burr then discusses the structure of the region, to show that the melaphyrs are not confined to a particular horizon or limited part of the sedimentary series and that they are not continuous at any horizon. These contentions must be conceded, and so far as I know have never been questioned; but they are certainly, to say the least, very inconclusive as arguments against the contemporaneous origin of the melaphyrs; for there is no apparent reason why the volcanic activity should have been sharply localized in time, and certainly aerial continuity is no more essential to effusives than to intrusives.

The account of the structure of this area on pages 61 to 66 fails to indicate that the main features had been previously described. Reference may be made especially to the detailed account of the thrust fault between the slate and the northern conglomerate. This is fully described and figured in my Contributions to the Geology of Eastern Massachusetts, published in [illegible]; I described it again and with additional emphasis upon its structural importance in 1882 (Proc. Bost. Soc. Nat. Hist. [illegible] 22-27), and still again in 1886, in my lectures on the Geological History of the Boston Basin.

[illegible] write in the interest of [illegible] the impetuous following [illegible] logical conclusion, regard- [illegible] arguments, which Mr. [illegible] surprising since the author [illegible] geological work; and the [illegible] in a hasty study, under [illegible] more than ordinary ener- [illegible] example of Mr. Burr's [illegible] what may be hoped from [illegible] brilliant paper of a year go on a new Lower Cambrian fauna from Eastern Massachuetts, which I have elsewhere described as unquestionably the most important contribution to the paleontology of the Boston Basin since the discovery of Paradoxides by professor W. B Rogers, nearly fifty years ago. W. O. CROSBY.

Institute of Technology, Boston, April, 1901.

PERSONAL AND SCIENTIFIC NEWS.

DR. H. E. GREGORY has been promoted professor of physical geography at Yale University.

PROF. G. H. BARTON, of the Massachusetts Institute of Technology, plans to spend the summer in Europe.

PROF. S. CALVIN, of IOWA CITY, recently visited Montana for the purpose of making a special examination of the Great Falls coal basin.

DR. T. NELSON DALE has resigned as instructor in geology and botany at Williams College, and will leave Williamstown during the summer.

MR. W. S. GRESLEY, of Eria, Pa., sailed for England on April 17th, where he is to take up professional work in connection with mining and geology.

THE OFFICE OF THE STATE GEOLOGICAL SURVEY OF MISSOURI has been moved from Jefferson City, the capital, to Rolla, where the State Mining School is situated.

RICHARD P. ROTHWELL, founder and editor of the *Engineering and Mining Journal,* and editor of the yearly volumes of *The Mineral Industry,* died at his home in New York City on April 18th.

AT A RECENT MEETING OF THE BOARD OF TRUSTEES of the Ohio State University John A. Bownocker was promoted to be professor of inorganic geology and Charles S. Prosser to be professor of geology and head of the department.

IT IS SAID THAT FOR THE FEW OPEN POSITIONS on the Geological Survey of Canada, a hundred applications have been received. This competition is due in part to the interest in geology awakened by recent developments of an economic nature in the Dominion.

MR. THOMAS W. ALLEN, St. Joseph, Mo., reports the discovery of a very fossiliferous stratum of gray sandstone about 60 feet above the bed of the Missouri river at that place, 12 to 14 inches thick. The rock is a mass of fossil plants consisting of ferns, calamites, Lepidodendrons, Sigillaria, broad-leaved plants, nuts, fruits, seeds etc. many varieties.

GEOLOGICAL SOCIETY OF WASHINGTON.—The program for the meeting of April 3d, was as follows: "The priceite of Lone ranch, Curry Co., Oregon," J. S. Diller; "The problem of Archean," C. R. Van Hise. At the meeting of April 10th the following was the program: "The Philadelphia gneisses," Miss F. Bascom; "Possible Pre-Wisconsin tills of Massachusetts," M. L. Fuller; "The Waverly group of Ohio." G. H. Girty.

NATIONAL MUSEUM FOR CANADA.—In the supplementary estimates to be laid before parliament in the course of a few days there will be included a substantial sum of money to be devoted toward the erection of a national museum of geology and natural history for the magnificent collection now accommodated in the Geological Survey building, Sussex street. The edifice will be of sufficient size and in design worthy of the purpose to which it is to be put.

DR. R. A. F. PENROSE of the *Journal of Geology* editorial staff, is about to undertake a journey around the world for the purpose of visiting the mines and mineral deposits of greatest interest. It is his intention to begin with the older Cornish tin mines and the chief mineral localities of England. Thence he intends to pass to Sweden and after visiting her principal objects of interest, to proceed by steamer from Stockholm to St. Petersburg. When he has completed his tour of observation of the mines and minerals of Russia he will go via the trans-Siberian railway to the Pacific and back to the diamond and gold fields of South Africa. Ceylon and Burmah will be visited, if possible, and he will return to California in a year or more.

J. PIERPONT MORGAN, the financier of New York City, one of the trustees of the American Museum of Natural History, was the donor of the Bement collection to that institution. This is probably the finest donation of minerals ever made to any institution. It is valued at from $150,000 to $200,000, and was called after Clarence S. Bement, of Philadelphia, who began the collection 35 years ago, and kept adding to it until it passed from his possession. Neither time nor money was spared in gathering desirable specimens, and in 1884 the Bement collection was looked upon as so important as to call for a special report in the interest of the National Museum, Washington. It was expected at one time that this collection would become the property of the government. A curator of a foreign museum, after seeing the Bement collection went to Europe. He cabled that he would purchase the specimens, but did not succeed in raising the necessary money. Since 1884 the Bement collection has increased over 50 per cent.

These accessions to the collection raise the American Museum of Natural History to rank among the museums of the world like that of the British Museum, heretofore, by common consent, considered as rich beyond comparison in rare specimens.

Neutaconkanut's Great Boulder.—This was described by Dr. C. T. Jackson in his report on the Geological and Agricultural survey of Rhode Island in 1840. It is in Johnson, near Providence. It is shown in a halftone cut in the *Providence Journal* of March 24. The boulder still rests where it did in 1840 and for centuries previous. The traveler in passing still takes a second look to see if it is really about to topple over and roll down the hill into the highway. It is a striking feature of the landscape, and will ever remain as an object lesson to the geologist, and a topic of interest to the casual observer.

Following is Dr. Jackson's description: "The rocks on Neutaconkanut Hill are alternate strata of micaceous and hornblende slate, the former being very much contorted. On the south side of the hill there may be seen a huge boulder of hornblende rock poised upon the mica slate. This rock must have originated elsewhere, and it now rests in an accidental position, as will be evident to anyone who examines the situation in which it is placed. Since hornblende rocks do occur at the northward, and not to the southward of the place where this block is now found, we feel confident that this immense rock has been removed southwardly from its parent ledge and deposited on the rocky strata where we now find it."

Field Work Methods in Geology at Harvard.—The elementary laboratory and field course at Harvard this year has enrolled about 190 men. The class is divided into three sections and each section into three companies for field work. The following memorandum has been issued to each student as a reminder of what he may expect to find in the field excursions. The assistants in charge of each company follow up this outline with questions and remarks called out by the particular locality. The students' results are handed in at the close in the form of a brief report with maps and sections.

Geology 5. Field Season of 1901. Brief Synopsis of Queries Answerable by Personal Observation.—Ask yourself on arriving at a locality selected for study whether it is an area of *erosion* or *deposition.* If an area of *erosion,*—what agent or agents are now at work or have been at work in the immediate past? Waves, currents, rivers; winds; ice or glaciers; life; weathering, disintegration, decomposition? What land forms have resulted from erosion? What new deposits have been made?

If an area of *decomposition.*—what materials are accumulating? What is their form? What is their structure?

In the case of a *rock in situ,*—what kind of rock is it? *If*—(a) *an igneous rock,*—What is its form? Batholith, laccolith, dike, sill, lava-flow, volcanic neck? What is the country rock? Where are the contacts? Is it intrusive? What is the mineralogical composition of the rock? What is the structure of the rock? Crystalline, porphyritic, glassy or devitrified? Has it flow structure? Is it vesicular, amygdaloidal, spherulitic?

(b) *A veinstone.*—What mineral or minerals compose it? What has been the order of their growth or genesis? What is the country rock? Did it furnish the substances in the vein? What is the nature of the cavity in which the vein is deposited? What rock movements ar shown? Is there any volcanic breccia? When did the vein form in relation to other structures or rocks?

(c) *A clastic rock.*—What is it? A conglomerate? If so, what rocks form the pebbles? What is the cement? How was the conglomerate formed? If a sandstone, what is it composed of? What is the cement? If a pelite, what is its structure, lamination, banding, or stratification? Are there fossils?

(d) *A metamorphic rock.*—What is its structure, composition? What was it originally? What has produced the metamorphism?

In any case, what is the attitude of the rock? strike, dip? Has it been jointed, folded, faulted, tilted, metamorphosed? Has it slaty cleavage? dip and strike of same? What is the age of the rock relative to others of different kind? In what order do the secondary structures intersect?

What has been the succession of events in the area studied?

THE SPENDIAROFF PRIZE.—The following letter may perhaps explain itself: Le Congrès géologique international, dans sa séance générale du 25 Août 1900, a nommé membres de la Commission du prix international Spendiaroff: MM. Albert Gaudry, président; Marcel Bertrand, Sir Archibald Geikie, Karpinsky, Tscherneyschew, Zirkel et Von Zittel. Cette Commission propose comme sujet de prix pour 1903:

Revue critique es methodes de classification des roches.

Dans la séance du 20 Août 1900, le Conseil du Congrès avait décidé que les ouvrages présentés pour le concours seront envoyés au Secrétaire général du dernier Congrès au nombre deux exemplaires au moins, et que l'envoi sera fait au plus tard une année avant la session suivante. Le Conseil a décidé aussi que le droit de priorité pour obtenir le prix appartiendra aux œuvres traitant les sujets proposés par le Congrès.

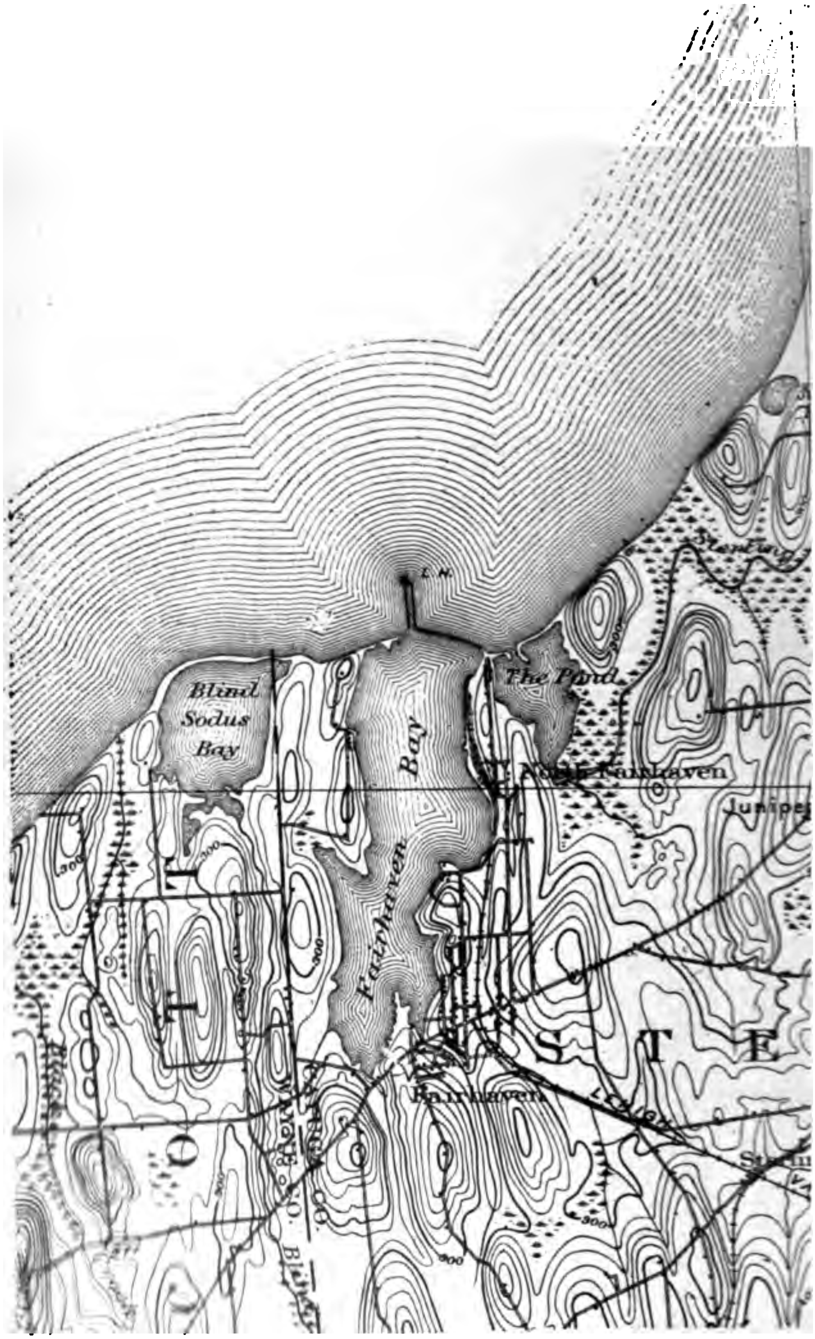
Les envois doivent être addressés à M. Charles Barrois, Secrétaire Général du Congrès géologique international, 62 boulevard Saint-Michel, Paris.

La valeur du prix est de 456 roubles, c'est-à-dire environ 1.200 francs, d'après l'indication de M. Karpinsky.

En vous communiquant ces renseignements, nous avons l'honneur de vous prier d'en faire part aux savants qu'ils pourraient intéresser.

Veuillez, Monsieur, agréer l'expression de nos sentiments les plus distingués.

ALBERT GAUDRY, Le Président du Congrès.
CHARLES BARROIS, Le Secrétaire général.



PORTION OF THE OSWEGO SHEET, U. S. G. S. MAP.

THE
AMERICAN GEOLOGIST.

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THE ONTARIO COAST BETWEEN FAIRHAVEN AND SODUS BAYS, NEW YORK.

By J. O. MARTIN, Cornell University, Ithaca, N. Y.

PLATES XXVI and XXVII.

During the summer of 1900, while engaged in a study of the New York state drumlin area, I became interested in the peculiar shore phenomena of that part of the Ontario coast lying between Fairhaven and Sodus bays. The drumlins which so thickly beset the south-lying plain are here brought to an abrupt termination by the erosive action of the lake. The resulting coast line, being of an unusual type, has seemed to me worthy of a brief description.

Viewed from a boat passing along shore, this coast presents a series of semi-elliptical bluffs which are wave-cut drumlin sections and these bluffs are connected, one to another, by low-lying beaches. A closer inspection of these drumlin cuts shows them to be composed of the usual stiff boulder clay, which, in this case, contains a very large percentage of Medina sandstone. The intervening beaches are composed of the coarser gravel and boulders of this drumlin till with little or no sand. Between the drumlins and behind their connecting beaches, lies a series of more or less extensive ponds and swamps. The above features are well shown on the accompanying map, (pl. XXVI), which is a part of the "Oswego Sheet" of the United States Geological Survey map and may be taken as typical of the whole stretch of coast under consideration.

At the close of the Glacial period when lake Ontario had assumed its present level, the drumlins extended out into the lake, forming a quite continuous series of islands. The general northeast and southwest trend of this coast exposed it to the most violent and frequent winds of our northern climate: consequently and because of the absence of bed-rock its development has been quite rapid. When wave erosion first began to cut into the drumlins, sea cliffs were formed on all sides of the drumlin islands and traces of these cliffs still exist, in some cases with large trees growing thereon.

As a result of their more exposed position, however, the northern ends were cut back most rapidly and then began the growth of the connecting beaches. The waves loosened [illegible] the drumlins more material than they could grind up and [illegible] material began to travel along shore, moved by the diagonally approaching waves, now in one direction, now in the other, but always gaining in the direction away from the most frequent winds. Slowly beach-bars grew out from each end of the sea-cliffs on the northern end of the drumlins, and these joined with those of the neighboring drumlins, tying them togeth[illegible] and producing a continuous coast line.

On the drumlins where wave erosion is most rapid, [illegible] vertical cliffs are formed and the stiff drumlin till expose[illegible] the combined action of weathering and erosion assumes [illegible] most fantastic forms. Buttress-like projections stand out [illegible] the cliff face, their upper edges reduced by rain erosion [illegible] sharp, thin, knife-like edges. Between these buttresses are ditch-like depressions down which streams of mud flow during wet weather. On such of the drumlins as are tree-covered there is a continual down-sliding of undermined trees and the farmers of this region, well knowing how rapidly their land is disappearing, place only temporary fences along the cliff edges. The very steepness of the cliffs of boulder clay show[illegible] how rapid this wearing back must be.

As the drumlin cliffs are cut back by wave erosion, the beaches are constantly changing their form and moving shoreward. From the data obtained from the farmers who note the necessary moving of fences and the shrinking of their fields, I have estimated that the cuts are moving backward from a few inches to ten feet a year where cutting is most rapid. Since the retreat of both the sea cliffs and beaches depends upon the rapidity with which the waves grind up and carry away the material loosened from the drumlins it is interesting to note the following fact which indicates, in a way, how rapid this

cess is

My first visit to this coast was in the spring. At this time, ving to thawing and to the great quantities of water in the umlin till large masses of clay were constantly sliding down the waves. As a consequence of this rapid supply the aches in front of the cuts had large numbers of the characistic angular and striated pebbles so abundant in drumlin . A visit three weeks later to the same point showed very w angular pebbles and these few had evidently just fallen wn. In the short period of three weeks, then, the hard edina sandstone pebbles had been so worn down as to have ost all traces of their angularity.

The ponds and lagoons in the rear of the beaches receive the whole of the land drainage and consequently the sediment which the streams are bringing down. The sediment is deposited in the ponds while the water flows into the lake, either by filtering through the porous gravel beaches, or, as in the case of "The Pond" (see map), by keeping for itself an open passage through the beach. Sediment and abundant aquatic vegetation are rapidly filling these ponds and in some cases have completed their task.

By a reconstruction of the truncate drumlins (see map), one can see that there has been a retreat of the off-shore beaches and drumlins of from a fourth to half a mile. As to how much farther north these drumlins extended we have no certain data; but the presence of several boulder pavements at a considerable distance off shore, having the basal outline of drumlins, seems to indicate the former positions of drumlins which have been completely cut away. These boulder pavements are of very large boulders, such as the waves would have been unable to remove. Just such boulders are now to be seen off the northern ends of the existing truncated drumlins.

We have in the formation of the above described interdrumlin beaches a striking illustration of the power of waves as a transporting agent and proof of their importance in shore phenomena. Professor Tarr, in a paper on "Wave Formed Cuspate Forelands,"* calls attention to the importance of wave transportation as a cause for many cuspate forelands; and since waves seem to me the most important along-shore agents, I have made some observations which show in a definite man-

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* *American Geologist*, vol. xxii, 1898, p. 1.

[illegible]

[illegible] map [illegible] there is [illegible] eastern beach, which is [illegible] by the earth [illegible] of the lake [illegible] of the water in [illegible] a strong on-shore wind the [illegible] the level of the water in [illegible] the lake. When the wind [illegible] the lake again with a consid- [illegible] however, is not able to carry [illegible] the more powerful waves. [illegible] important factor and the [illegible] currents in the lake, is ca- [illegible] sand and clay.

EIGHTH SESSION OF THE INTERNATIONAL CONGRESS OF GEOLOGISTS, PARIS, 1900.

ITS PROCÈS VERBAUX WITH RUNNING COMMENTS.

PERSIFOR FRAZER, Philadelphia, Pa.

A volume, royal 8vo of 62 pp. has been issued by the French ministry of commerce, trade, post and telegraph giving the procès verbaux of the eighth session, held at Paris last year from the 16th to the 27th of August. The promptness with which all the publications of the last Congress have been issued, is an unmistakable indication of the directing power of Charles Barrois, the able general secretary.

After an enumeration of the twenty-five excursions, follow the more or less formal addresses of the retiring president, Karpinski (who was re-called to Russia a few days afterwards by a death) and of the incoming president, Gaudry. The announcement by the latter of the deaths of the former members of the Council, Lieut. General de Tillo, Hauchecorne, Janettaz, James Hall and Marsh seems to have been erroneously printed "since 1878" (the date of the first meeting of the Congress in Paris). In point of fact all these eminent men appear to have died since the St. Petersburg session of 1897. In Barrois' report the happy solution of a difficulty which threatened the success of these International Congresses is announced. It was to organize two sets of excursions, the first open to practically any one who cared to take part, but the second restricted to professional and practising geologists. For several sessions the local committees have staggered under the increasing burden of providing for the transportation and maintenance at a minimum price of great numbers of persons, chiefly foreigners to the country where the session was held, who read in the newspapers of the excursions planned for the geologists, and determined to profit by them as personally conducted tours to which the payment of an entrance fee of twenty-five francs, entitled the payer. This imposition was most severely felt at the St. Petersburg session in 1897.

Six months before the opening of the session, the newspapers throughout the world had announced the generous plans of the Russian local committee to carry two or three hundred members of the Congress in special trains, steamers, and [illegible] attacks. The benefits [illegible] many persons [illegible] geology [illegible] a number of [illegible] The gentleman [illegible] statements [illegible] the writer [illegible] the upper [illegible] of the extreme good [illegible] of the non-geological [illegible] the great [illegible] and employing about [illegible] 235 passengers [illegible] geologists [illegible] what they saw but kept fully [illegible] from taking part.

[illegible] States had a larger [illegible] in this fraudulent practice [illegible] The debates upon [illegible] without result. The method of M. [illegible] compared to a lightning arrester [illegible] least friction.

[illegible] committees were presented [illegible]

[illegible] by M. Tschernyschew.

[illegible] Capellini on behalf of the [illegible]

[illegible] M. Zirkel.

[illegible] Richter.

[illegible] Sir Archibald Geikie on international co-[illegible] investigations.

[illegible] Gilbert on the reproduction of types.

[illegible] Spendiaroff prize was as follows. Gaudry [illegible] Sir Archibald Geikie, Kar-[illegible] Zirkel and v. Zittel.

[illegible] Spendiaroff award was also happy in [illegible] M. Spendiaroff from becoming a [illegible] the administration of the Congress.

[illegible] of this foundation is peculiar.

[illegible] month of excursions prior to the St. Petersburg Congress [illegible] young man was noticed by all participants, and especially by the foreigners, for his grace and courtesy in assisting them, and his intelligence and zeal in the science of geology. During the beautiful Volga steamboat excursions he will ever be remembered by those who were present for his delightful singing of the Russian folk songs, both alone and in chorus. One day in St. Petersburg at the morning session of the Congress, after the Ural and other ante-session excursions had finally come to a close, the members were shocked to learn of the sudden death of young Spendiaroff. A few days afterwards the president, M. Karpinsky, announced the donation of his father to found a prize in memory of his son. The object was most laudable, but many of the members, including Hæckel, feared lest the precedent should be abused by persons desirous of securing international notice.

The committee appointed to determine the method of applying this fund has placed it in the Russian treasury to the credit of the Russian Geological Survey, and the minister of agriculture and domains has offered the interest of the 4,000 Rubles to the International Geological Congress for a prize to be offered under such conditions as the congress may choose.

This relieves the difficulty of any direct dealings between the congress and individuals, and avoids the necessity for such an organization of the former as would enable it to hold and administer funds. On the whole, in its present shape the donation may prove beneficial.

It is amusing to note that Karpinsky, without whom the Spendiaroff prize would never have been attached to the International Congress of Geologists, was the first to receive it nolens volens, although two sessions of the council were occupied with his efforts to avoid this honor.

Vienna was named as the place of the meeting in 1903.

On Archibald Geikie's motion, a committee (Geikie chairman, Horne, Dawson, Tschernyschew, Sederholm, Ramsay, Chamberlin, Brögger, Reusch, de Geer, Högrom, Barrois,) was appointed to secure more uniformity in the relative studies of the coast lines of the northern hemisphere—and another (Credner and v. Zittel, Mojsisovics, von Mojsvar, Tietze, Geikie, Teall, Renard, Walcott, Chamberlin, Barrois, de Lapperent, Capellini, Karpinsky, Alexis, Pavlow, Brögger, Renevier.) to ascertain in what direction international coöperation in geological investigations is most required.

Karpinsky and Stefanescu report for Russia and Roumania respectively that these countries have accepted the suggestion of the previous congress in reference to instruction in geology in the public schools.

M. Karpinsky reports as to the creation of a floating museum which has presented such great difficulties. It was referred to the Geikie committee on international coöperation.

M. Oehlert's committee to procure photographic representations of types of fossil species consists of Bather, Woodward, Frech, von Zittel chairman, Mojsisovics, v. Mojsvar, Uhlig, v. d. Broeck, Fraipont, Walcott, Williams, Almera, Gaudry, Oehlert secretary, Canavari, Kjöer, Stefanescu, Pavlow, and Tschernyschew, Choffat, Lindström, Lorriol. It was pointed out that the commission should hasten its work in order to show a commencement in 1903 at Vienna.

The council legalized by vote the practice which has hitherto always obtained of relegating to the management of each council the execution of the work of a congress until the next session of the congress.

The Meetings of the Sections.

I. *General Geology and Tectonic.*

Archibald Geikie the president of the section delivered his address on international coöperation, etc. (Note.—It were greatly to be desired that James Geikie, the president's talented and learned brother, took a more active part in these congresses. Especially would his assistance be of value in the section presided over by his ex-official brother.

The papers were:

M. J. Joly. 1) Geological age of the earth determined by the content of sodium in the ocean; 2) Experiments concerning denudation by fresh and by salt water. 3) Order of formation of silicates in igneous rocks. 4) Internal mechanism of marine sedimentation.

M. de Lapparent. On the limit of geological stages.

M. Stanislas Meunier. Subterranean denudation.

M. Bleicher. The denudation of the Vosges.

M. Richter. Report on the works of the Glacial Commission.

M. J. Vallot. On the movement of glaciers.

M. Arctowski. The former extension of glaciers in the regions discovered by the Belgian antarctic expedition.

M. Popovici-Hatzeg. The new geological map of Roumania.

M. [illegible]. Proposition tending to simplify the notation of dip and strike of beds.

The abbe Parat. The grottoes of La Cure.

II. *Section of Stratigraphy and Paleontology.*

V. Zittel presiding in place of Renevier detained by illness.

The suggestions of the committee have only moderate interest or novelty.

One is to substitute "Eo" for "Paleo," but it has not occurred to the proposer of the change what would be the fate of "*Eozoic*" and "*Paleo-zoic,*" both terms of great value. As to eras, Gaudry prefers the terms primary, secondary, and tertiary.

Prof. Scott presents to the section the fauna of Patagonia, through the studies of J. B. Hatcher. The series of beds is thus arranged:

Gault; containing Ammonites resembling entirely the synchronous fauna of the South of Africa.

Magellian; a terrane of Eocene or Oligocene age.

Patagonian; very fossiliferous Miocene of which the fossils are closely allied to those of Australia and New Zealand.

Santa Cruz; beds fossiliferous fresh-water Miocene with mammifers of which the fauna is more closely related to the southern Australian fauna of Africa than to the northern of America.

Beds of Cape Fairweather; Pliocene age.

M. Bertrand by "gelosic and humic coals," comprehends the boghead coals and bituminous schists. His paper is original and interesting.

M. Grand Eury. On the rooted stems of the Carbonic terranes.

M. Lemeire. Methodical connection explanatory of the chemical formation of various fossil combustibles.

M. H. F. Osborn. 1) "Progress of methods in Paleontology." 2) "Correlation between the mammiferous faunæ and the Tertiary horizons of Europe and America."

The conclusion of this last study is that in these two regions of the northern hemisphere the paleontology and stratigraphy accord; that the progress of evolution is parallel if not identical; and that the same divisions into stages may be permitted.

M. Ficheur presented the third edition of the geological map of Algeria on a scale of 1 : 800,000.

M. Flamand. "Geology of South Algeria, high plateaux and mountains of Ksour. and the regions of Sahara."

M. Donville. 1) "The Jurassic terrane of Madagascar." 2) "The geological results of the exploration of M. Morgan in Persia."

M. Zeiller. "The fossil plants of Tonkin."

M. Malaise. "The Cambric and Siluric in Belgium."

M. Oehlert, proposed the foundation of an international publication for the purpose of re-editing the types of described species anterior to a certain determined epoch. This proposition was referred to the Council.

[illegible] The [illegible] of S[illegible] [illegible]
[illegible] The [illegible]

III. [illegible] Mineralogy and Petrography.

M. Michel-Lévy as president of the international commission on petrography, read the following suggestions which the foreign scientific members approved.

First suggestion. The names of the authors shall always be placed after the names of the rocks as is the custom in zoology and botany.

Second suggestion. That the congress name an international committee to publish the new names of rocks with as precise a description as possible, with their chemical analyses and, if necessary, with an illustration reproducing their structure. This publication will take place in the transactions of the congress.

The committee appointed consists of: Rosenbusch, Weinschenk, Zirkel, [illegible], [illegible], Tschermak, A. Geikie, Judd, Teall, [illegible], [illegible], Hussak, Adams, Ussing, [illegible], [illegible], Iddings, [illegible], Fouqué, Lacroix, Michel-Lévy, Barrois, Ramsay, Sederholm, Sabatini, Strüver, [illegible], [illegible], [illegible], Mrazec, Karpinsky, [illegible], Loewinson-Lessing, [illegible], Duparc, Schmidt, [illegible]. This committee has the right to add to its number.

Third suggestion. It is desirable to regulate the nomenclature of [illegible] rocks where the lack of unity is particularly felt [illegible] different authors attribute different significations [illegible] the same name, and conversely different [illegible] names are employed to designate the same rock, the [illegible] of rocks of the same structure. All these inconsistencies of nomenclature can and ought to be abolished. At [illegible] great groups.

Fourth suggestion. The characteristic of the great group [illegible] shall be based upon the mineralogical [illegible] composition and structure [illegible] dissenting votes. Löw[illegible] composition shall be the [illegible] the great groups, received

[illegible] groups can be determined at

once, without interfering with the ultimate development of the classification and dismemberment of these groups in subdivisions. Adopted.

Seventh suggestion. It is desirable to designate the principal types of structure by special names. Adopted.

Ninth suggestion. It is necessary to avoid the employment of the same denomination (of identical term) in different senses. Adopted.

Tenth suggestion. The employment and creation of different terms to designate the same idea, the same rock, or the same group of rocks, should be avoided wherever possible. Adopted.

Thirteenth suggestion. The employment of pre-existing names, or the assignment to them of a new meaning, by restricting or enlarging their significations, should be avoided wherever possible.

The secretary exhibited the proof of the petrographic lexicon of M. Loewinson-Lessing.

M. Zirkel was elected president of the commission of Petrography. An executive committee of the petrographic committee was chosen, consisting of Becke, Barrois, Brögger, Loewinson-Lessing, Pirsson.

IV. *Section of Applied Geology.*

M. Mourlon. "The new paths of Belgian geology."

M. Gosselet. "The salt waters met in the aquiferous areas in northern France.

M. Van der Veur. "The enlargement of the Kingdom of the Netherlands by the drawing of the Zyderzée."

M. Thevenni. "The plateaux of the Hautes Pyrénées and the dunes of Gascony."

v. d. Broeck. "The applications of geology."

M. Kunz. "The progress of the production of precious stones in the United States."

M. L. Janet. "The enclosing and protection of the springs of potable water."

M. de Richard (read by the president). "The origin of petroleum."

Final General Session.

M. Matthew, Jr., presented in the name of his father a note, printed by the congress, on "The most ancient paleozoic faunæ."

An interesting episode was the reading by the secretary-general, M. Barrois, of a passage from a note by M. Walcott, director of the U. S. Geol. Survey, on "Fossiliferous pre-Cambric formation," in which, relying on the testimony of M. Rauff, he doubts the existence of the organisms described by M. Cayeux in the pre-Cambric of Brittany. After the reading, M. Rothpletz stated that with M. Renard he had seen the sections described by M. Cayeux and considered the existence of the Radiolaria in these preparations indubitable.

M. Pavlow. 1.) "The Portlandian of Russia compared to that of the Boulonnaise." 2) "Some methods which might contribute to the elaboration of a genetic classification of fossils."

M. V. de Broeck. "On the Bernissartian."

M. A. Guebhard. "Tectonic phenomena of the Alpes maritimes."

The president announced the receipt of a written communication from MM. Lohest and Forir on "The method of numbered notation of terranes."

M. Stanislas Meunier. "The structure of the diluvium of the Seine."

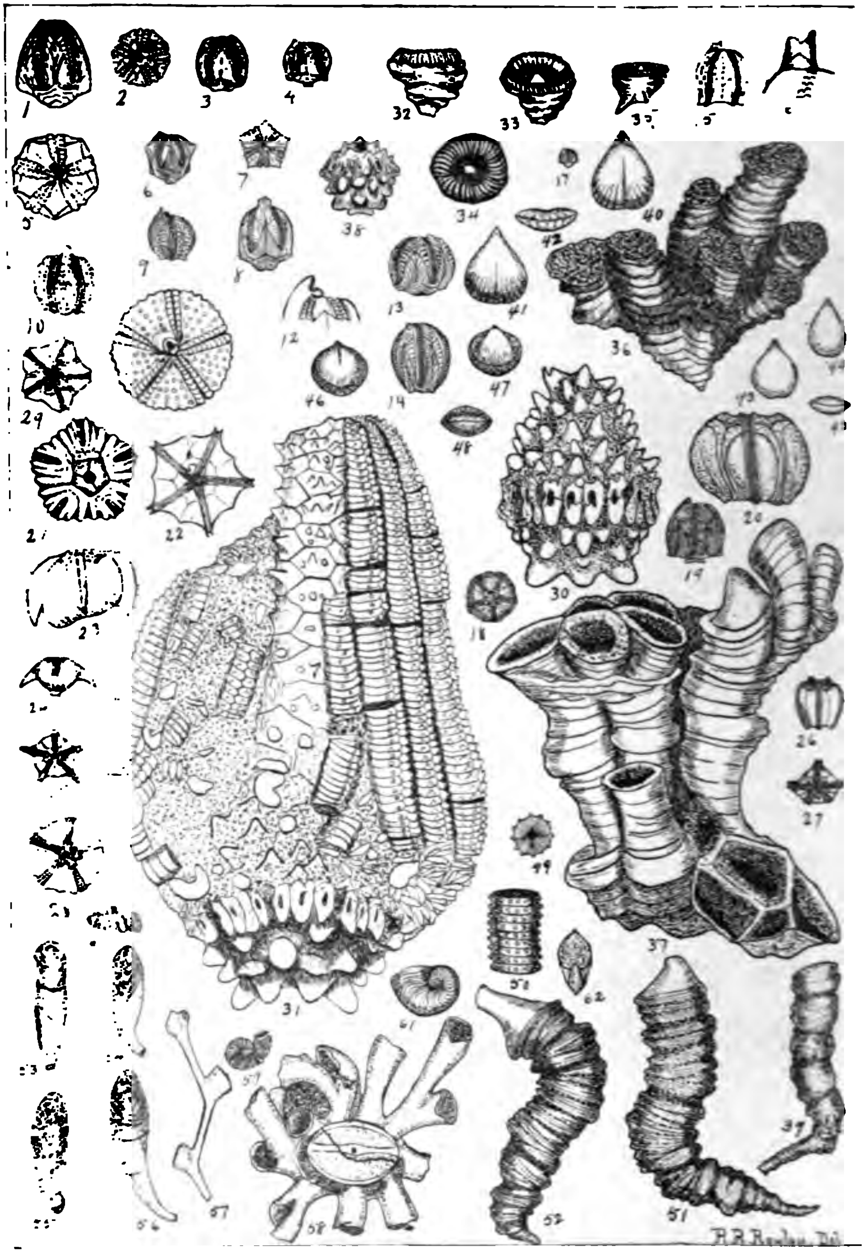
The Secretary-General resumed a note from *M.* ***Hull*** on "Suboceanic terraces and valleys of the western rivers of Europe." Also a note from

M. Huddleston, on "The eastern border of the Atlantic."

M. E. A. Martel. "The general geological and hydrological results of the subterranean explorations which the author has undertaken since 1888."

M. G. Dollfus. "The last geological phenomena of which the Seine and Loire have been the theater."

The late congress is pledged to publish before the expiration of the year a volume containing not only the transactions but important memoirs accompanied by fine illustrations.



FOSSILS FROM THE UPPER PALEOZOIC OF MISSOURI.

TWO NEW GENERA AND SOME NEW SPECIES OF FOSSILS FROM THE UPPER PALAEOZOIC ROCKS OF MISSOURI.

By R. R. Rowley, Louisiana, Mo.

PLATE XXVIII.

It is our purpose here first to discuss two little groups of blastoids of which scarcely anything is known to the general student of this class of organisms, since they are not only very limited in their distribution, but even locally reckoned among the rarities.

Of group one, the first mention is probably to be found in Dr. Shumard's description of *Pentremites roemeri* in the old "Missouri Geological Survey, I and II Reports, 1855." Imperfect as the description is and poor as the figures are, the author had before him a specimen of what has since been described as *Granatocrinus sampsoni.* It was hardly a medium sized individual and without surface markings, but with the rather large interradial (deltoid) and distinctly convex base. (I refer to his figure 2a. Figs. 2b, 2c and 2d represent another and quite distinct thing.)

Along with his figure of *Granatocrinus sampsoni,* Dr. Hambach figures one of Dr. Shumard's specimens, but it is certainly specimen no. 2 (2b, 2c, 2d as above) and can hardly stand for *G. roemeri.*

The type of the latter species came from the Chouteau limestone of Providence, Boone Co. Later collectors have found this form near Sedalia, Pettis Co., and in the Kinderhook beds at Osceola and Cedar Gap. The author of this paper has found it at both of the latter places and has obtained specimens of it from the other places mentioned.

The next species of the group brought to the notice of naturalists is the *Codonites inopinatus,* passing over the problematical *Pentremites neglectus,* too poorly defined and ill figured to be able to be identified even generically.

Codonites inopinatus was figured and described in the Kansas City *Scientist,* July, 1891.

In the August number of the same journal and same year the third species was defined and figured as *Granatocrinus aplatus.* Two more species will follow the generic description here.

This group of blastoids presents some striking characteristics, and is further removed from Orbitremites (Granatocrinus) than Cryptoblastus is. The base is either level with the lower ends of the ambulacra or decidedly convex. The basal plates form a low broad cup, thus separating widely the lower ends of the ambulacra. The interradials (deltoids) are rather large, often quite a third of the length of the fossil, while the anal plate is sometimes extravagantly produced upward to form a hood over the anal opening and pushing out towards the center so as to reduce the usual star-shaped central opening to a lunule. The spiracles are small and, although known for some time in *Granatocrinus aplatus*, have been discovered but recently in *Codonites inopinatus*. They are hardly round in any of the species and decidedly elongate in the last two mentioned species, thus approaching, as we have always suspected, the slits of *Orophocrinus*.

The prominence of the radial or fork pieces along the sutures, gives rise to elongate depressed triangles bordering the ambulacra, and across these triangles the lines of ornamentation run as on the deltoids, or interradials, recalling the side-plate areas on Orophocrinus. The ambulacra are either even with the surface of the radials and interradials or stand out bead-like above them.

The tops of the radials at the common suture are generally prominent and sometimes so much so as to give a strongly pentagonal cross section and a decidedly Codaster-like appearance to the specimen.

The ornamentation is either linear, sometimes very fine and again cord-like in its coarseness, or toothed-linear and possibly granulo-linear.

We propose for this little group the generic name of *Lophoblastus* in allusion to the crest-like hood over the anal opening, and make *Codonites inopinatus* the type species of the genus. We offer the following generic diagnosis: Body conoidal, elliptical or quite globose; ventral side generally convex, but sometimes flat; base large, flat or decidedly convex; deltoids or interradials large, sometimes a third of the entire body length; radials or fork pieces from one-half to nearly three-fourths the length of the whole body; ambulacra even with the radial lips or above them; Spiracles ten in number and vary from punctures to slits; anal opening surrounded by an elevated rim and often strong hood-like upper prolongation of the anal deltoid or interradius; ornamentation, fine lines, coarse cord-like folds, or crenulated lines; columnar cicatrix rather large, but the column is unknown, so also the pinules. The central opening above (ventral) confined to a lunular area and, in perfect specimens, covered by an integument of small plates.

The genus begins in the Kinderhook or the so-called Lower Chouteau beds and extends through the Lower Burlington.

Lophoblastus conoideus, n. sp.

PLATE XXVIII.

Fig. 1.—Side view, two diameters, of a large specimen.

Fig. 2.—Ventral view, two diameters, of another specimen.

Fig. 3.—Side view of a large elliptical specimen, natural size.

Fig. 4.—Side view of a specimen, probably of a different species.

Body small, conoidal or elliptical. Base large, convex and composed of the usual three plates. Columnar scar medium in size and excavated. Interradials from one-fourth to one-fifth the length of the body. Radials more than half the length of the body. The lower ends of the ambulacra project outward. The spiracles are round or slightly elongate openings and the anal opening is rather large and with a less pronounced hood than any of the other species, excepting *Lophoblastus roemeri*. The ornamentation is fine or coarse lines parallel with the plate sutures. The elongate triangular areas bounding the ambulacra as marginal parts of the radials are less pronounced than in the type species.

The specimens of this species were collected from Upper Chouteau beds, two and one-half miles northeast of Curryville, Mo.

This fossil was figured along with *Granatocrinus mutabilis* under the impression that it belonged to the same species, but better specimens lately obtained show the greatest difference between them.

Lophoblastus marginulus, n. sp.

PLATE XXVIII.

Fig. 18.—Ventral view of a specimen with the central opening covered by an arch of minute plates extending a little way over the ambulacra.

Fig. 19.—Side view of the body of the type specimen, showing the character of ornamentation and the little rim around the stem base.

The collection contains four of these little blastoids. The base is flat or a very little convex. The lower ends of the ambulacra are separated by a rather broad base made up of the usual three pieces. The columnar base is surrounded by a distinct rim, giving a slightly concave surface for attachment. The radials (fork pieces) are hardly more than half the greatest length of the body. The interradials (deltoids) are more than a third of the length of the body. The ambulacra are more convex than the radial and interradial borders and the interambulacral areas are flat or concave and three of the four specimens are decidedly pentangular in cross section but this may be due in part to the fact that the test is very thin and the three specimens in question may be a little misshapen, due to pressure.

There are ten elongate or slit-like spiracles and an anal opening with a hood but less prominent than in *L. aplatus.*

There is no elevation above the general surface at the tops of the radials as in *L. opinatus* but the ornamentation is the same as in that species (fine longitudinal lines), the cross lines of the deltoids continuing down the sides of the ambulacra as elongate triangles on the radials to the very end of the ambulacra. The mid-interambulacral triangular areas of the radials are crossed longitudinally by fine lines. The type specimen is 7½ mm. long and about 7 mm. wide. The basal rim is a little over 2 mm. wide.

This blastoid comes from the brown, earthy layer just over the top of the fifth division of the Lower Burlington limestone and is associated with *L. aplatus, Aorocrinus wachsmuthi, Agaricocrinus planoconversus* and *Cactocrinus springeri* Hart's and Pratt's Quarries, Louisiana, Mo.

An average specimen of Lophoblastus conoideus is about 4 mm. in length by 4 mm in breadth. A large specimen 6mm. in length by 4½mm. in breadth. A small specimen 2½mm. in length by 3mm. in breadth.

The species of this genus at present known are,

Lophoblastus inopinatus, Lower Burlington limestone.

Lophoblastus aplatus, near top of Lower Burlington limestone.

Lophoblastus conoideus, top of Choteau limestone.

Lophoblastus marginulus, top of Lower Burlington limestone.

Lophoblastus roemeri, Kinderhook or Lower Chouteau limestone.

Lophoblastus (?) neglectus, Lower Burlington limestone

The other group embraces three already described species and a new one here figured and described for the first time. *Granatocrinus magnibasis* was defined in the October, 1895 number of the AMERICAN GEOLOGIST, *G. piriformis* in the August, 1891, number of the Kansas City *Scientist*, and *G. stella* in the February, 1900, number of the AMERICAN GEOLOGIST.

We propose for this group the generic name *Carpenteroblastus*, as a slight tribute to our friend the late Dr. P. Herbert Carpenter, of Eton College, England, and take for the type species *Granatocrinus magnibasis.* The distinguishing characters of the new genus are sunken ventral surface; narrow, elevated ambulacra; broad, convex basal disk; coarse, cord-like ornamentation, and usually distorted appearance; rather small deltoids, eight small rounded spiracles (two more are probably confluent with the anal opening), and a small anal opening. None but the young of *C. magnibasis* have symmetrical shapes, while most of the specimens of *C. stella* are similarly and singularly misshapen, the only one preserving the test, however, is quite regular in outline. *C. stella* differs much from the other species in the free ends of the ambulacra and consequent great prominence of the base. The new species is represented by a single specimen and that is in a crushed condition. It will be known as,

Carpenteroblastus pentagonus, n. sp.

PLATE XXVIII.

Figs. 26 and 27.—Side and ventral views of the type specimen. This little blastoid is about 6 mm. long by 5½ mm. broad; has small deltoids, long fork pieces and a flat, not large base; the ventral side is concave. The spiracles are small, round and the anal opening is inconspicuous. The ambulacra are narrow and convex beyond the radial edges. The interambulacral areas are flat. The ornamentation is hardly noticeable on the type specimen.

This rare bastoid comes from the same horizon as *Lophoblastus aplatus* and *L. marginulus* (top of the fifth division of the Lower Burlington limestone) at Louisiana, Mo.

The species of this genus at present known are,

Carpenteroblastus magnibasis, base of Upper Burlington limestone.

Carpenteroblastus piriformis, Upper Burlington limestone.

Carpenteroblastus stella, base of Upper Burlington limestone.

Carpenteroblastus pentagonus, top of fifth division Lower Burlington limestone.

Aorocrinus wachsmuthi, n. sp.

PLATE XXVIII.

Fig. 38.—Side view of the type specimen, natural size.

This little crinoid has nodose calyx plates and blunt spinose ventral plates. The central dome spine, so conspicuous in Dorycrinus is represented by a nodose plate in this species. The basal plates form a low rim about the top of the column. The first radials are very nodose and about as long as wide. The second radials are smaller, quadrangular pieces. The third plate in the radial series is a bifurcating piece and five-sided, and a little smaller than the second radial. The interradials consist of one large noduse plate, upon which rest two flattened plates above. The anal interradial area is filled by a large plate in line with the first radials and a little larger than them, supporting three smaller nodose plates above and resting on the latter in turn are three smaller flat plates. The anal opening is on a wart-like prominence. Three of the arm lobes give off two arms each while the right and left anal lobes give off three each, making 12 arms in all. The stem base is very small and round.

We are glad to name this pretty little species for the late Charles Wachsmuth of Burlington, joint author with Mr. Frank Springer of the genus *Aorocrinus*.

This crinoid is found associated with Lophoblastus aplatus and another Aorocrinus, apparently a variety of *A. parva*, near the top of the fifth division of the Lower Burlington limestone at Louisiana, Mo.

In our notes on the "Fauna of the Burlington Limestone at Louisiana, Mo.," AMERICAN GEOLOGIST, Vol. XXVI, October, 1900, page 247, we mentioned a specimen of Schizoblastus sayi with a short proboscis. We here figure this little specimen to show this feature. Another specimen has since been found showing the same structure. Figs. 15 and 16; the latter is an enlarged view.

Fig. 30 is a side view of a splendid body of *Cactocrinus springeri*, a crinoid figured and described by the author in the February, 1900, AMERICAN GEOLOGIST, as *Batocrinus springeri.*

Fig. 31 is a large body, somewhat crushed, with three entire arms and parts of three others. The great ventral tube is preserved to the arm tips and furnished with spines. The arms are traversed longitudinally by short spiny nodes in rows. Associated with these crinoids are spiny stems which, doubtless, belonged to this species.

Axophyllum ? alleni, n. sp.

PLATE XXVIII.

Figs. 32, 33, 34.—Side and ventral views of the largest specimen.
Fig. 35.—Side view of a smaller specimen from Weston, Mo.
All drawn natural size.

The specimens of this species are short and broad, with the top of the lamellae arched and above the epithecal covering of the outside, even more pronounced than in Microcyclus. The lamellae or septa number about sixty (60) and are rather crowded. The central boss or columella of the shallow cup is strong, rounded and low, or triangular, and is formed of the upturned inner edges of the lamellae or septa. The cups show no other feature than those mentioned. The outer surface or epithecal covering is considerably wrinkled and folded. The base is acute and with or without radicular appendages.

Its distinguishing characters are the shallow cup, upper edges of the septa arched above the outer epithecal covering, shallow almost discoidal outline, short but stout columella

It comes from the Upper Coal Measures of Northwestern Missouri. Specimen, figure 35, is from Weston.

The specific name is in honor of Mr. Thomas W. Allen, of St. Joseph, Mo., an excellent collector in the Upper Coal Measures of western Missouri and one to whom the author is indebted for many favors.

Leptopora ramosa, n. sp.

PLATE XXVIII.

Fig. 36.—Side view of the type specimen, natural size.

Two specimens of this peculiar coral are in the author's collection and both are pointed below and expand above by the multiplication of stems from the parent stalk, due to lateral gemmation. The corallites are more or less round, very rugose and irregular in shape. The cups are very shallow and where the sides and bottoms are weathered, appear cellular. No septa are visible and are probably wanting, but placenta are probably present as in *L. placenta*, although not seen in the types.

This species occurs in the Chouteau limestone, east of Curryville, Mo., associated with Leptopora placenta and other corals.

Leptopora procera, n. sp.

PLATE XXVIII.

Fig. 37.—Side view of the type specimen, natural size.

The base of this coral differs but little from Leptopora placenta, being flattened and with large shallow cups and a very wrinkled and rugose epithecal under surface but in producing tall crowded stems above by calicular budding, it differs from all the species of Leptopora with which the author is acquainted. The stems spring from the shallow cups below, are more or less round, very rugose and distorted and, crowding together at the top, the otherwise round cups become polygonal. From the calyx of one of the stems three small stems arise. No septa are observable nor are placenta, but the latter are surely present. The cups are shallow and are pitted or cellular in appearance.

The fine specimen figured was obtained from the Chouteau limestone at Annada, Mo.

Trigeria? curriei, n. sp.

PLATE XXVIII.

Figs. 40, 41, 42.—Views of the brachial and ventral valves and the front of the shell, respectively, twice natural size or two diameters.

Shell longer than wide, plicated but with the plications more or less obsolete, except near the front of the shell. Young individuals, however, are plicate throughout. The beak of the pedical valve is rather long and pointed with a triangular area beneath it and a delicate triangular foramen. Nothing is known of the inside of the shell. The shells vary from 1½mm. to 6 mm. in length and from 1 mm. to 6 mm. in width. The specimen figured is 5 mm. by 4 mm. (length and breadth.) There is a slight sinus at the front margin of the brachial valve and sometimes one on the pedicel valve also. It is rather a rare form in the Louisiana (Lithographic) limestone at Louisiana, Mo. It is obtained, among other small forms, by washing the clay from between the limestone layers.

This little brachiopod is named specifically for Rev. H. Currie, of Thedford, Ontario, an excellent collector in the Hamilton group and a most obliging scientist.

Dielasma? pediculus, n. sp.

PLATE XXVIII.

Figs. 43, 44, 45.—Brachial, pedicel and front views of a large specimen, two diameters.

Length of a large specimen 4½, width 3½ mm.

This little shell is smooth, rather flat, elongate, with a rather long pedicel beak, the end of which is perforate. It occurs abundantly in the clay seams of the limestone and is obtained by washing the soft material. It is found associated with the above species, Ambocoelia minuta and Chonetes geniculata in the Louisiana limestone at Louisiana, Mo.

Nucleospira barrisi? (white.)

PLATE XXVIII.

Figs. 46, 47, 48.—Three views of the brachiopod, natural size, as it occurs in the Louisiana (Lithographic) limestone at Louisiana, Mo.

It is not plentiful. There is some doubt as to the correctness of the specific reference.

Cyrtolites bennetti, n. sp.

PLATE XXVIII.

Figs. 61 and 62.—Front and side views of the type, natural size.

The aperture of this shell is elongate, heart shaped. There is a mid-dorsal fold and the strong lateral lines of ornamentation curve sharply toward this fold. The inner whorls are hidden by the outer. This shell is 7½ mm. wide and is very rare. It is named for my friend, Rev. John Bennett, of Kansas City, Kan.

It occurs about the middle of the Lower Burlington limestone at Louisiana, Mo.

Spirorbis? dubius, n. sp.

PLATE XXVIII.

Figs. 59, 60.—Two views of the type specimen, natural size.

This little shell was free and has no appearance of ever having been attached.

It is composed of three irregular whorls, more or less distorted and crossed by sharp ridge-like lines. It coils loosely. This species is almost certainly not Spirorbis but its generic relations are doubtful and for the present we leave it under Spirorbis. It is 5 mm. wide.

It comes from near the middle of the Lower Burlington limestone at Louisiana, Mo.

Amplexus vermicularis, n. sp.

PLATE XXVIII.

Fig. 51.—Side view showing nearly the entire length, natural size.

Fig. 52.—Another view showing the contracted cup, natural size.

This peculiar fossil has the external appearance of Amplexus but despite the excellent preservation of the type specimen, the septa are not visible through the epithecal covering and are to be seen only on a weathered spot, and, doubtless, are merely raised lines along the inner side of the outer wall.

The external surface is beautifully ornamented by irregular cross ridges and crowded lines of growth. Placenta are, doubtless, present but not seen in the type specimen.

The example figured is entire, rather elongate, distorted and contracted in places, yet gradually enlarging toward the front. The strangest feature of the type specimen is its contracted calix, giving the appearance of a second end for attachment and no open cup. The contraction begins about 1-3 of an inch from the anterior end and is almost closed at the front. Were it entirely closed the question might be asked, can this be an opercutate coral? Other specimens apparently of the same species but less robust and more elongate, have fine crowded septa but hardly developed beyond the appearance of raised lines and with placenta crossing the central open space at irregular intervals without curvature. This fine coral is from the third division of the Lower Burlington limestone at Louisiana, Mo.

Amplexus radigerus, n. sp.

PLATE XXVIII.

Fig. 39.—Side view of the type, natural size.

Coral elongate, differing little in cross diameter, except where the stem makes rapid contractions.

Shape irregular, often abruptly bending to the right or left. The cup is not clean in the type specimen, but is apparently deep and the septa poorly developed, but seen on the surface as fine crowded lines. On the inner side of the surface wall they are more pronounced than in *A. vermicularis*. Cross lines of growth and ridges of distortion gird the exterior. Tabulae at irregular intervals cross the central area. A few short radicular appendages occur along the lower half of the coral.

Another Amplexus, probably distinct, with little greater diameter than this form, is often found several inches long and apparently incomplete, alternately contracted and exponded, but without radicular appendages.

This coral comes from the third division of the Lower Burlington limestone at Louisiana, Mo.

Coleophyllum? greeni, n. sp.

PLATE XXVIII.

Fig. 53.—Side view of a nearly perfect coral, natural size.

Figs. 54, 55, 56.—Side views of other specimens, weathered in such a way as to show structural features, natural size.

This coral is elongated, curved and without septa (lamellae). The cup is shallow. The entire fossil is made up of a series of invaginated tabulae, as seen on the weathered specimens. The outer surface is comparatively smooth except near the calix where the edges of the tabulae remind one somewhat of Cystiphyllum.

The specimens are from the Upper Chouteau limestone, three miles northeast of Curryville, Mo.

Aulopora longi, n. sp.

PLATE XXVIII.

Fig. 57.—Side view of a large stem, natural size.

This is a slender, elongate species. The tubules are very long with the oral portion rapidly expanding. Each coralite comes off from the one below it in such a way as to give a zigzag appearance to the stem. This species is probably attached at the base but never along the side.

It occurs both in the Lower and the Upper Burlington limestones at Louisiana. Some specimens are quite two inches long. The specimen figured is from the base of the Upper Burlington limestone. It is a much more delicate species than *A. gracilis*. We are glad to name this coral for Mr. F. R. Long, of Louisiana, Mo.

Aulopora amplexa, n. sp.

PLATE XXVIII.

Fig. 58.—View of a colony surrounding joints of a Platycrinus stem, natural size.

This is a much stouter coral than either *A. longi* or *A. gracilis* but near to the latter, except in its manner of growth. The colonies are always found surrounding stem joints of crinoids, especially Platycrinus and, sometimes, as in the type specimen, between two stem joints, pushing them apart and surrounding them. The tubules are rather large, short and little expanded at the orifices.

Stem joints of Platycrinus are often found in the Burlington limestone with from two to four or five conical holes reaching almost or quite to the center of the stem and sometimes showing remnants of a tubular form filling each hole. Is this our Aulopora?

This species comes from the base of the Upper Burlington limestone, at Louisiana, Mo.

EXPLANATION OF PLATE XXVIII.

Lophoblastus conoideus, n. sp.

Fig. 1. Type specimen. Side view x2.

Fig. 2. Ventral view of another specimen, showing the anal opening and the ten small, round spiracles x2.

Fig. 3. Side view of a specimen, more globose and with finer ornamentation x1.

Fig. 4. Side view of a broad specimen apparently granulo-striate x1.

Fig. 17. Side view of a young specimen, natural size.

Lophoblastus inopinatus Rowley & Hare.

Fig. 5. Ventral view of a specimen showing the anal opening and the short slit-like spiracles x2.

Figs. 6 and 7. Side and ventral views of a specimen with a strong pentagonal outline at the top of the radials, natural size.

Fig. 8. An elongate specimen, side view, showing the shape and great hight of the anal hood. Natural size.

Lophoblastus aplatus Rowley & Hare.

Fig. 9. Side view of a medium sized specimen, natural size.

Fig. 10. Side view of a larger specimen, showing ornamentation and the hight and shape of the anal hood, natural size.

Fig. 11. Ventral view of a specimen to show the anal opening and elongate spiracles, x2.

Fig. 12. Side view of the top of a specimen to show the hood and anal opening, x2.

Lophoblastus roemeri Shumard.

Fig. 13. Side view of a medium sized specimen, showing the coarse character of ornamentation, natural size.

Fig. 14. Side view of an elongate specimen with flat base, natural size.

Lophoblastus marginulus, n. sp.

Fig. 18. Ventral view of a plump specimen, showing the central opening closed by a covering of small plates that extend out for a short distance over the ambulacra. Natural size.

Fig. 19. Side view of the type to show the beautiful ornamentation, broad base and the expanded columnar disk or rim. Natural size.

Carpenteroblastus magnibasis Rowley.

Fig. 20. Side view of a specimen to show the character of ornamentation, x1.

Fig. 21. Basal view of the same, natural size.

Figs. 22 and 23. Ventral and side views of a natural cast from chert to show the great thickness of the test about the ambulacra and the usual unsymmetrical character of the species. Natural size.

Fig. 29. Ventral view of a smaller specimen, preserving the test and showing the spiracles and anal opening, natural size.

Carpenteroblastus stella Rowley.

Fig. 24. Side view of the type, showing specific characters, natural size

Fig. 25. Ventral view to show the anal opening and spiracles, natural size.

Carpenteroblastus pentalobus, n. sp.

Figs. 26 and 27. Side and ventral views of the type, natural size. (Specimen somewhat crushed.)

Schizoblastus sayi Shumard.

Fig. 15. Side view of an undersized specimen, preserving the base of a little ventral tube. Natural size.

Fig. 16. Top of the same specimen, enlarged to four diameters, to show the plates in the tube.

Fig. 28. Ventral view of a somewhat larger specimen, having the central opening closed by a covering of minute plates, passing out over the ambulacra for a short distance. Natural size.

Aorocrinus wachsmuthi, n. sp.

Fig. 38. Side view of the type specimen. Natural size.

Cactocrinus springeri Rowley.

Fig. 30. Side view of a fine body, natural size.

Fig. 31. A specimen showing the heavy spinose ventral tube and the heavy nodose arms, x1.

Figs. 49 and 50. The column of this crinoid, end and side views, natural size.

Leptopora ramosa, n. sp.

Fig. 36. Side view of the type specimen, natural size.

Leptopora procera, n. sp.

Fig. 37. Side view of the type specimen, natural size.

Axophyllum ? alleni, n. sp.

Fig. 32. Side view of the largest specimen, natural size.

Fig. 33. Same with the calix turned a little toward the observer.

Fig. 34. Same, calix view.

Fig. 35. Side view of a smaller specimen. All figures of this species. natural size.

Amplexus radigerus, n. sp.

Fig. 39. Side view of the type specimen, natural size.

Amplexus vermicularis, n. sp.

Fig. 51. Side view, natural size, showing nearly the entire length.

Fig. 52. Another view showing the contracted cup, natural size.

Chonophyllum greenei, n. sp.

Fig. 53. Side view of an unworn and nearly entire specimen, natural size.

Figs. 54, 55, 56. Side views of worn specimens, showing the invaginated tabulæ.

Aulopora longi, n. sp.

Fig. 57. Side view of the type specimen, natural size.

Aulopora amplexa, n. sp.

Fig. 58. A specimen surrounding a platycrinus stem joint, natural size.

Spirorbis? dubius, n. sp.

Figs. 59 and 60. Two views of this peculiar fossil, natural size.

Cyrtolites bennetti, n. sp.

Figs. 61 and 62. Front and side views of the type specimen, natural size.

Trigeria ? curriei, n. sp.

Figs. 40, 41, 42. Brachial, pedicel, and front views of a large specimen. x2.

Dielasma ? pediculus, n. sp.

Figs. 43, 44, 45. Brachial, pedicel and front views, x2.

Nucleospira barrisi? White.

Figs. 46, 47, 48. Pedicel, brachial and front views, natural size.

ORE FORMATION ON THE HYPOTHESIS OF CONCENTRATION THROUGH SURFACE DECOMPOSITION.

By Charles R. Keyes, Des Moines, Iowa.

In seeking a suitable explanation for the localization of ore materials from an assumed generally diffused condition in the country rock, a number of recent writers have leaned towards the idea that through the surface decomposition and degradation of the land the heavy materials in large part remain behind and tend to concentrate into ore deposits, the extent of which in any particular instance is to be regarded in a measure proportional to the amount of general erosion which that region has undergone.

This hypothesis has received special attention in the consideration of the lead and zinc deposits of the Mississippi valley.

Its application, however, has not been confined to this region. It has been extended to other mining districts, even those in which typical fissure veins abound.

Since the most advanced conceptions regarding the nature of erosion have gained such wide hold among geologists, ore students have seized with avidity upon some of these principles as furnishing a long sought for solution to the manner of many concentrations of ore bodies. The attractive features of the hypothesis are many. But objections have not been so obvious, and have not generally presented themselves. These last mentioned phases of the subject have entirely escaped the notice of mining engineers and special students of ores from the mining side. To geologists who have given geographic development special attention, the objections appear formidable, and in many instances unsurmountable.

Winslow* formally states the hypothesis when he says that it "starts with the proposition that the metalliferous minerals originally existed in the Archean rocks, either in a disseminated condition or in veins. With the decay of these early rocks, the minerals became diffused through later-formed sediments, this diffusion being quite uniform over contiguous areas. Successive decaying of successively formed rocks simply resulted in a transfer of these minerals." Accordingly, the concentration process was entirely subsequent to the period of rock formation. "It is, primarily, a result of great and long-continued surface decay of the rocks; and, secondarily, the result of the presence of local favorable physical and chemical conditions."

This general statement presents numerous slight modifications with different writers. Its advocates agree that the diffused ore-materials are, as degradation of the land goes on, carried downward to lower and lower levels, the metal-accumulating zone retaining always a constant relation to the ground surface. From this proposition two main phases proceed. One would retain the ore materials in a diffused condition; the other in a concentrated form, or as an enrichment of the lower zones.

The principles of geologic geography demonstrate beyond all doubt that lands elevated are worn down to near sea-level with far greater rapidity than has been generally supposed.

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* *Missouri Geol. Sur.*, vol. vii, p. 477, 1894.

The fact that in many localities enormous denudation has taken place in the past, has been for a long time widely recognized. But that profound erosion, thousands of feet in depth, may easily take place in a single geological epoch or period, instead of during one or several long geological eras is a proposition which has not been so universally appreciated.

If we apply to any particular locality either phase of the hypothesis that generally diffused ore materials are concentrated through surface decomposition of the country rocks, we should expect to readily find abundant facts in substantiation. Either the ore materials of a region should give evidence of unusual original accumulation through the phenomena of local sedimentation; or the concentration should be about proportional to the amount of erosion.

With regard to the first of these propositions, students of ores are now pretty well in agreement that such factors as oceanic currents can no longer be considered as appreciable factors directly affecting the localization of ore deposition through solution. Besides, there are so many secondary factors entering into the problem, that even if the truth of the proposition be assumed, it would be utterly impossible to adduce proofs, so completely would they be obscured by attendant features. In the light of recent geographic and geologic research, all theoretical deductions appear to militate against the possibility of such conditions.

The second proposition presents some objections not met with in the first. The theoretical deductions are conclusive. The practical demonstrations present no very great difficulties. In the case of the Ozark region, of which a special example has been made, the facts are singularly against the hypothesis advanced.

The analyses made by Robertson* of Missouri rocks, show the presence of lead, zinc and copper in minute quantities. While the number of determinations made is far too small to enable any broad generalizations to be stated, it is significant that those rocks taken from the mining localities contain a very much higher percentage of metallic contents than those collected from localities remote from ore bodies. The inference would naturally be that the present difference in the amounts of the metals in these rocks is due largely to the same concentration which produced the existing ore bodies.

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* *Missouri Geol. Sur.*, vol. vii, p. 479, 1894.

The analyses mentioned were made for the express purpose of supplying evidence to the theory of the general diffusion of metals in rock masses. Winslow's hypothesis* is that in the Ozark region the rocks have suffered enormous denudation, and consequently the metallic substances that were diffused through the portion eroded have settled down, and have been redeposited in the constantly lowering zone at or near the ground surface.

Curiously enough for this hypothesis, along the summit of the Ozark dome, where decomposition and denudation have been greatest (by some 4,000 feet or more than at the margins) there are practically no ore bodies of consequence. The richest and most extensive deposits are at the very base of the uplift, in a district which has not only suffered a minimum amount of denudation, but which has not been removed more than the northern part of the state of Missouri, where no deposits whatever occur.

In a very localized form the same hypothesis is claimed to be applicable to true fissure veins. This phase of the subject has been lately emphasized by Weed† in the consideration of the gold and silver deposits of Montana. This author also calls special attention to the ore bodies of the Australian Broken Hill Consol mine of New South Wales, as described by Smith,‡ and to the Aspen district of Colorado, described by Spurr.§ He says: "Active degradation favors the accumulation of enrichments, while prolonged degradation of a region, resulting from physiographic revolutions, may result in successive migrations of material and the accumulation in a relatively shallow zone of the metals derived from many hundreds, and possibly thousands, of feet of the vein worn away in the degradation of the land. Climatic conditions, rainfall or aridity, warmth and rapid alteration of vein fracture are agents affecting surface weathering, and hence, also, enrichment.

"Active degradation of a region, that is, rapid weathering, favors enrichment by the quickness with which it removes the upper already leached part of the vein, so that a large amount of the vein matter is lixiviated in a given time than would result from slower wasting of the land. Such enrichments are favored by high altitudes. Moreover, the mountainous regions are those in which secondary fractures are most apt to be found."

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* *Missouri Geol. Sur.*, vol. vii, p. 469, 1894.

† *Trans. American Inst. Min. Eng.*, vol. xxx, 1900.

‡ *Trans. American Inst. Min. Eng.*, vol. xxvii p. 69, 1896.

§ *U. S. Geol. Surv.*, Mon. xxxi, 1898.

Blake's observations* on the formation of the lead and zinc deposits of the Wisconsin district have an import similar to that of Winslow's for Missouri.

Of like suggestion is Winchell's view† regarding the Wisconsin lead deposits and the Minnesota iron ores. This author regards the Cretaceous strata as having extended over the whole of the upper Mississippi valley region and in their removal to have allowed the ore materials to lodge in the porous and gashed Silurian rocks beneath.

These special examples have been noted in this connection for the reason that in all there is the same effort to seek an adequate and direct source for the ore bodies. All start with the assumption that the present ore bodies were derived from the ore materials that had settled downward as the great rock masses above were removed through erosion. In other words, the existing ore bodies of the region mentioned are claimed to be deposits the formation of which has depended wholly or largely upon the general metallic content of the country rock once existing above the present ground surface of the respective districts.

In none of these cases is it believed that the conclusions reached regarding the local source of the ore materials are either warranted by the arguments adduced, the facts as they are presented in the field, or the general geological conditions known to be prevalent in ore-producing regions.

In the case of the Ozark region, we have unusually complete data regarding the geological times of rapid erosion and the periods of peneplanation. There is abundant evidence showing that immediately after the deposition of the Lower Carboniferous rocks—the country rock of the southwest Missouri zinc district—the Ozark region was not the highland it now is. Between the time when the last Lower Carboniferous limestones were deposited and that when the first Coal Measures of Missouri were laid down, the strata were tilted and so profoundly eroded as to expose all formations down to the Cambrian; while in the south, in Arkansas, where sedimentation went on uninterruptedly, strata to a thickness of 20,000 feet accumulated. Along the horizon of this peneplain there is no evidence of notable deposits of ores of any kind.

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* *Trans. American Inst. Min. Eng.*, vol. xxii, p. 628, 1894.

† *Minnesota Geol. Sur.*, Bull. 6, p. 153, 1891.

Beds belonging to the upper part of the Coal Measures are now known to occur on the highest parts of the present Ozark dome. Small doubt therefore exists as to the extension of the Coal Measures (Des Moines and Missouri series) entirely over the region occupied by the great uplift. This is also, according to our best knowledge on the subject, probably true of the Cretaceous strata. Before, however, the deposits of the latter were formed another long period of erosion intervened. Yet in the known remnants of the peneplain which was formed at that time no signs of the existence of ore bodies are found.

Again, when the Ozark region was bowed up and planed off in Tertiary time down to the pre-Cambrian basement, no indications are presented that the peneplain which is the present general upland surface of the dome, is a horizon that is a special ore-bearing level. As already stated, it is in the central part where degradation has been greatest that ore deposition has been least.

We are forced to the conclusion, at least so far as the Ozark region is concerned, that degradation and surface decomposition even though so profound as to remove thousands of feet of rock, do not tend to concentrate whatever diffused metallic content the strata may contain. While profound surface decomposition is an important factor in the formation of ore deposits, by itself it produces no effect in this direction. There must also be special geological structures and special geological conditions always present before the localization of ore material is possible.

Without attempting to discuss or furnish detailed evidence at this time, it may be in this connection granted that most rocks actually do at all time contain in a diffused condition ample supplies of most common metals to furnish materials for the richest of ore deposits, that subterranean waters are constantly transferring laterally from one point to another metallic substances along with many others which are not ore-forming.

and that the leached substances from near the ground surface are being carried through faults, joints and cracks downward to lower levels. In addition to all this there must be special local geological conditions to be satisfied before ore bodies can begin to form.

There is a parallel example in the case of petroleum. Next to water, we now know that rock-oil is perhaps the most abundant substance circulating in the earth's crust. The Waterlime formation of Ohio and certain dolomytes of the Mississippi valley contain in each 500 feet of thickness upwards of 2,500,000 barrels of oil to the square mile. The oil contained in only three townships would thus be more than the total amount which has up to the present time been taken out of Pennsylvania and New York fields. In order to have an area economically productive a peculiar association of geological structures and conditions must exist. There must be a reservoir in the form of a porous or cavernous bed, a non-porous cover as afforded by a shale stratum, and a bowing up of the strata such as is presented by an anticline. The absence of any one of these precludes the accumulation of oil bodies. So in connection with the ores the conditions and structures may all be present but one and yet there will be a failure of ore bodies.

In the more special case, in which a concentration has already well progressed, as presented by a mineral vein or a lean ore vein, where enrichment has taken place below the zone of weathering through downward flowing currents, it does not appear probable that the ores from the upper part of a vein can be considered as furnishing the enriching materials for the lower portion. As openings, fissures of any kind are at best very ephemeral in character. In no instance can they be regarded as forming open water passages for any considerable period of time. They must be completely closed up long before surface degradation has advanced to any appreciable extent.

New fissures may open up in the rock, new fault movements may take place, new cracks may be formed, through which metalliferous solutions may find access to the old mineral vein or lean ore sheet, but only in exceptional cases would material from the upper part of a vein find lodgement lower down in the same vein. The waters affecting the surface of an ore sheet would ordinarily carry the decomposed materials far from the neighborhood.

The general metallic content carried by circulating waters would doubtless accomplish the same result of secondary enrichment of lean veins, but it would certainly be through other openings than that in which the original vein was formed.

In the particular examples cited by Weed* of the Mollie Gibson and Smuggler ore bodies and bonanzas, the enrichments are along the lines of secondary faulting and the alterations are only in the immediate vicinity of these later fractures. Many other similar examples might be mentioned.

The immediate practical importance of the distinction is perhaps not so great at the present time as is the fact that the plausibility of the hypothesis at first glance being so evident is likely to lead often to untrustworthy conclusions.

The conclusion seems inevitable that with the exception of possibly a few isolated unimportant instances ore concentration does not generally take place through surface decomposition of rock masses, in areas such as the Ozark lead and zinc region. As in the case of petroleum, if it be assumed that all rocks at all times contain ample supplies of metallic salts in a diffused condition sufficient for the most extensive ore deposits, and that the circulatory waters hold them at all times in solution to a greater or less but adequate extent, these must be regarded general, always present conditions. But concentration of metallic salts into ore bodies must be admitted to be accomplished under special local conditions of geological structure, quite independent of all rock decomposition and land degradation.

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* *Trans. American Inst. Min Eng.*, vol. xxx, 1900.

CONCERNING THE OCCURRENCE OF GOLD AND SOME OTHER MINERAL PRODUCTS IN IOWA.*

By Samuel Calvin, Iowa City, Iowa.

It is a source of constant wonder and surprise that, notwithstanding all that has been said and written, there are yet persons of influence, intelligent beyond the average in all other respects, who entertain the crudest conceivable notions concerning the facts of geology and the distribution of mineral resources. The highest natural gifts and the broadest scholarly training and business experience seem to be altogether ineffectual, in the absence of some training in the principles of geology, to protect men from the most amazing fallacies as to what may or may not be found below the surface of the ground. Samples of yellow mica from decayed Kansan bowlders, or iron pyrites from shales or limestones, are received almost weekly from persons who imagine they have discovered gold in Iowa. Small flakes of brass worn from the working parts of pumps or other farm machinery, are among the causes which have led to repeated reports of discoveries of gold in a region where not a single condition favorable to the presence of the precious metal exists. Probably the most wild and unjustifiable of all the crude beliefs respecting geological resources is that which holds to the conviction that by going deep enough the drill is sure to find something of value, no matter at what point the work of boring is commenced. There are numerous wise persons in every community, estimable, influential and in the highest degree public spirited, who are convinced that the question, for example, of finding coal in their special locality is simply a matter of the depth to which the explorations are carried. Rock oil and natural gas are recognized as desirable products in every progressive community, and every such community contains persons, in other respects intelligent, who are ready to stake their own fortune and that of their nearest friends on the belief that oil and gas are everywhere underneath the surface, and that their sources can be tapped with the drill, provided only there is sufficient capital to keep up the process of drilling long enough.

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*Advance sheets from the Reports of the Iowa Geological Survey, Vol. XI, pp. 17-27.

But is there no gold in Iowa? Men certainly have found some. Coal occurs in certain localities in the state, why are the chances not equally good for finding it in all other localities? Why is it not a good business venture in Iowa to explore the depths of the earth for gas and oil, when fortunes are made and cities are boomed by the discovery of these desirable products in other states? Why is it not a proper function of the Geological Survey to bore test holes in different localities in order to settle the question of the presence of oil and gas beneath the surface? To answer these questions fully would require much space and would involve a discussion of some of the most elementary principles of geology. Let me try as briefly as possible to present the facts necessary to an understanding of these subjects for the benefit of the non-geological reader.

Native gold, metallic gold, free gold—by whatever name it may be designated—occurs chiefly under two conditions. First, it is found in veins in the crystalline rocks. Such rocks are generally very old; they are fundamental; they occur at the surface in a broad belt around Hudson Bay—none of the newer or later formed rocks being present in that locality—and they extend down into northern Michigan, northern Wisconsin and northern Minnesota. They have been forced up near the surface and have been subsequently exposed by erosion in all mountain regions. As a rule, it is in mountain regions that gold is associated with them, for it is here that they have been fissured by the strains and movements which gave rise to the mountains. Various minerals have been concentrated in the fissures by circulating waters—the waters being more efficient if warm and alkaline—and among the minerals so concentrated we sometimes find gold. Gold-bearing veins in the crystalline rocks are the basis of all the lode mining; but it must be kept in mind that only a very small proportion of all the veins referred to carry gold. Now there are no true crystalline rocks anywhere near the surface in Iowa. All such rocks here are deeply covered with newer rocks of sedimentary origin. These sediments were laid down, one on the other, in slow and orderly succession, on ancient sea bottoms, in precisely the same way, and of precisely the same materials as the beds of mud and sand and limy ooze which are to-day accumulating on the marginal bottoms of the modern seas. Such rocks contain no gold-bearing veins, and hence it must be obvious that there can be no lode mining for gold in Iowa. In the second place, free gold occurs in placer mines. Placer mines are simply sheets of disintegrated rock material which has been strewn over the surface, usually along river valleys, by the action of flowing water. The rocks of mountains decay and are worn away by air, storm waters, frosts and other agents; the gold-bearing veins, if there are any, decay with the rest; the gold is freed from the matrix in which it was embedded, and the loose materials, gold and all, are gradually washed down to lower levels. The placer miner simply separates—by some convenient device—the gold from the loose clay and sand and gravel with which it is accidentally associated. It must again be obvious that, except in regions where there are gold-bearing veins, there can be no placer mines worth considering. From all this it will be easy for anyone to estimate the probability of finding gold in such a state as Iowa.

In apparent contradiction of all that has just been said it must be acknowledged that gold is occasionally washed out of the sand banks and river gravels within the limits of our state. Spread over the sedimentary rocks and forming our soils and subsoils, are sheets of drift which were transported and distributed by glaciers coming from the north. Some of the materials forming the drift at any given point were carried long distances, from away beyond the national boundary. In northern Minnesota and on the other side of the boundary line, in the Rainy Lake region, are quartz lodes carrying free gold. The ice sheets brought disintegrated materials from this region, as they did from all others over which they passed, and spread them out as part of the drift of Iowa. Some particles of gold came with the rest, and it is possible occasionally to discover some of them by panning carefully the loose surface materials. A resolute, industrious man, working persistently year by year, might possibly accumulate one or two dollars' worth in the course of a lifetime; but the business cannot be recommended as a profitable means of employing one's time. The resident of Iowa who imagines he has discovered a gold mine on his home farm is certainly basing his judgment on deceptive appearances of some kind.

To understand the situation in respect to coal a few things must be kept in mind. First, as every miner knows, the coal is interbedded with sedimentary rocks, usually with sandstone and shales. Second, sedimentary rocks were laid down one on the other, one after the other, in slow succession; and so the history of rock deposition in Iowa embraces a very long period of time. This history is almost complete from a period earlier than the introduction of life on the globe to times when land plants and animals were well developed. Third, coal was formed from land plants of certain types, the plants being preserved so as to be transformed into coal only under peculiar and favoring conditions. Fourth, coal plants did not come into existence until long after the beginning of the record preserved in the geological strata of Iowa. The older rocks, therefore, can contain no coal, because they were laid down long before any coal plants grew. All the rocks indicated on the geological map, Plate II, in Volume X, as Algonkian, Cambrian, Ordovician, Silurian, Devonian, and Mississippian, are older than any coal. The coal of Iowa occurs chiefly in the Des Moines formation; a little is found in the Missourian. It was while these two formations were in process of accumulation, not before, that coal plants of sufficiently luxuriant growth to count for anything existed in Iowa; and though these plants were abundant, it was only in certain favored and comparatively limited localities that the preservation of the plants took place so as to form coal. The geological formations of Iowa lie one on the other somewhat like the shingles on a roof, except that the oldest and first laid formations extend underneath the rest all the way across the state. The older formations appear successively from beneath the latter in going from the southwest toward the northeast. The Cambrian sandstones that are found in the sides of the valleys near Lansing, lie far below the surface at Des Moines. A well bored at Des Moines would pass, in the reverse order of their formation, through all the older beds, and would finally reach the Cambrian at a depth of about 1,600 feet. All these older beds, and all the individual layers of them, are seen in order, one after the other, between Des Moines and Lansing; and so a drill hole at Des Moines could reveal nothing of consequence that might not be learned by careful investigation of the natural surface exposures in the region between Des Moines and the northeast corner of the state.* Explorations for coal in the Mississippian, Devonian, Silurian, or older systems of rocks are foredoomed to failure for the simple reason that these rocks were all completed before a single workable coal seam was deposited, some of them before a single coal plant, or any terrestrial forms of vegetation from which coal might be formed, had come into existence. These formations all lie geologically below the coal. If one could begin in the Mississippian or lower formations underneath Des Moines or in that vicinity, and bore upwards he might have some chance of striking coal. But boring downwards in any of the formations referred to, whether under Des Moines or at points where the older beds come to the surface in the eastern part of the state, is going in the wrong direction; and the farther the boring is carried, the more hopeless becomes the search. There is positively no coal in any parts of Iowa, which have formations older than the Des Moines shales and sandstones as the surface rock. The finding of coal is not a question of deep drill holes, but is one of intelligent and thorough prospecting of geological deposits of a particular age. If the operation is begun in any formation older than the Des Moines, the drill may go through to Australia or anywhere else without finding a speck of coal.

Petroleum and natural gas are like coal in one particular—they are derived from organic products. They are known to have their origin in dark bituminous shale, in limestones, which are in general of organic origin, in quantities of vegetable matter included in sandstones, in remains of forests buried in the drift, in any accumulations of organic matter which have undergone or are undergoing decay while hermetically sealed from the atmosphere. The marsh gas, which is annually produced by the decay of vegetation at the bottom of ponds, affords an illustration of the origin of one of the products we are considering, familiar to almost every observant person. It need scarcely be said, therefore, that rocks which are older than the introduction of life on the globe can furnish neither gas nor oil; and the fact that such rocks may be reached in Iowa at no great depth makes it possible to explore the whole of the possibly productive series with comparative ease. Owing to their low specific gravity, oil and gas are displaced by descending waters and tend to rise toward the surface. They may, therefore, be found at some distance above the beds in which they are generated, but it would be very unusual to find them lower down.

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* The Greenwood Park well at Des Moines has penetrated to the Cambrian and has put to actual test the statements which any competent geologist would have made in advance. All the broad details of that boring could have been written out beforehand. The full record of the well, to the minutest details, is given in Norton's *Artesian Wells of Iowa*, Iowa Geol. Sur., Vol. VI, p. 294 *et seq* Scores of other deep wells scattered throughout Iowa and confirming all that would be inferred from studies of the superficial exposures, are described in the same volume.

The seas were practically destitute of life when the Algonkian quartzytes at the base of the Iowa geological column were laid down, and all rocks older than the quartzytes were formed under conditions even less favorable. It may be very positively affirmed that explorations for oil or gas below the top of the Algonkian are certain to be fruitless. Above the Algonkian lies a body of Cambrian sediments—mostly sandstones—1,000 feet in thickness. Life was far from abundant in Iowa during the deposition of the Cambrian, though even if it had been never so prolific, it would have counted for little, since sandstone is not a good conservator of the organic matter present in the seas at the time of its accumulation. Sandstones are good reservoirs for the storage of gas and oil after these products have been generated from some underlying productive rock. But there is nothing below our Cambrian from which gas or oil could be derived, and so the probability of finding either below the top of the Cambrian sandstones is so small as to be unworthy of consideration. Overlying the Cambrian are two formations, the Oneota and the Saint Peter, equally as barren as anything below them. When the drill reaches the top of the Saint Peter sandstone, it has practically passed through and beyond all formations in which there is any possible hope of finding the products under discussion. Next in ascending order comes the Trenton limestone, a formation that was laid down on a sea bottom fairly crowded with swarming forms of life. This limestone is impure; it contains a large amount of clay mixed either with the materials forming the layers of stone or laid down as beds of shale between the more stony layers. The Trenton formation was deposited under exceedingly favorable conditions for making it a productive source of gas and oil. It still contains large quantities of bituminous matter which by the slow distillation always going on must yield annually considerable volumes of gaseous or liquid hydrocarbons. At all the exposures of the lower Trenton, from Dubuque northward, the dry shaly partings between the ledges of limestone afford material so rich in bitumen that it is easily lighted with a match; it burns freely and emits a strong oily odor. Bituminous shale, precisely like that seen in the natural exposures, was brought up from the horizon of the Trenton in the deep well at Washington, Iowa; it has been recognized in other deep wells; the same shales, rich in bitumen, probably underlies the greater part of the state.

If then a great amount of bitumen is stored up in the Trenton limestone and is constantly evolving gas and oil by slow distillation, why are not gas and oil wells as common in Iowa as in the productive regions of Ohio and Indiana? Let it be answered that something more than petroleum-bearing rock is needed in order that oil may be obtained in quantities of commercial importance. It has been estimated by professor Orton that the rocks beneath the surface over a very large part of Ohio contain at least 3,000,000 barrels of oil to the square mile, and yet not one gallon of this can be secured by the drill without the concurrence of at least two other conditions: (1) There must be a porous reservoir—sandstone or porous limestone—in which the oil or gas may accumulate, and this must be covered with shale or other impervious deposit to prevent the hydrocarbons from escaping to the surface and becoming lost as fast as they are generated. But reservoir and cover alone will not insure a supply. So long as the rocks lie flat or have a uniform dip there will be no accumulations of any importance. (2) The reservoir and cover must present a series of folds beneath the arches of which the oil and gas are entrapped and accumulated under high pressure. Three conditions, therefore, must exist conjointly—the source of supply in some form of organic matter, the porous reservoir and impervious cover, and the arched or folded condition of the beds. It is the last of these conditions that is wanting in Iowa. Our stratified rocks are not folded to any noteworthy extent. The compression and crushing which gave rise to the Appalachian mountains produced folds as far west as Indiana, and then the effects fade out. Iowa is too far away from other centers of crustal disturbance, such as the Ozark region of Missouri or the great mountain axes of the west; and so the rocks are without the folds which are so essential to the accumulation of the fluent hydrocarbons. Besides the Trenton limestone there are petroleum-bearing rocks in other formations in Iowa, notably in the Carboniferous; but so far as discovery has gone, some of the conditions on which accumulation in commercial quantities depends, are always absent. Usable quantities of gas have been found at a few places in Iowa in the drift. This gas has its origin in the buried forests; beds of sand and gravel constitute the reservoir; and overlying bowlder clay is the impervious layer. Near Herndon and Letts are wells of this kind. The volume of gas is small; its source is near the surface; nothing would be gained, but much might be lost, by deeper borings. If either oil or gas is ever found in Iowa in usable quantities, outside the drift, it will be found either in or above the Trenton. There is no possibility of its occurring below that formation. Now, remember that deep wells which have penetrated the whole thickness of the Trenton and gone hundreds of feet below it, are scattered all over Iowa. Every one of these wells, no matter for what purpose it was made, is, in effect, a test hole for gas and oil; and every one of them answers the question of the occurernce of these products in a way that might be inferred from what is known of the geological structure—namely, in the negative. The state has been very thoroughly explored beyond the deepest point at which there is the slightest hope of success, and a thousand other test holes would not make the situation any clearer or the results more decisive. There is always the very remote possibility that there may be a small arch somewhere which has not been pierced by the drill, but the chances of its existence are so few, that if the object is simply to test for gas or oil, it would be an unjustifiable waste of money to search for it even if holes could be bored everywhere down into the Trenton limestone at the rate of one dollar apiece. The geological structure of the state, in its broader features, is now thoroughly known. The records of the many deep wells, so fully and accurately described by Norton in Volume VI of the Iowa Reports, reveal that structure in scores of places down to the Algonkian; and from the base of the Algonkian to the earth's center, there is nothing but barren, igneous rocks in which drills might be worked eternally without the remotest prospect of finding even so much as a trace of gas or oil.

There is another fallacy which should be disposed of, if it is ever possible to dispose of any of the popular and deep-rooted fallacies concerning what is hidden from ordinary observation beneath the surface of the ground. However it has arisen, there is a wide-spread belief that experts in some way are able to judge of the presence or absence of valuable products by an examination of the topography and general characteristics of the surface of any given region. Unscrupulous persons, taking advantage of this belief, have robbed some Iowa communities unmercifully. Such persons usually own an elaborate outfit for drilling, and naturally they want to keep themselves and their machines employed. The community to be victimized is easily selected. With specious claims of expert knowledge and glib assurance that this hill and that ravine and the relations of the level plain all bear unmistakable evidence of underlying wealth of the very kind that the community for the moment most desires, the requisite amount of money is quickly coaxed from the pockets of the public spirited subscribers, the hole is bored, the driller gets his pay, and the community is left to repent its folly at its leisure. Not infrequently it is the public spirited men of the community who take the initiative, and, without knowledge of their own and asking no advice, but firm in the belief that the earth will yield anything desired if we only go deep enough, they proceed with the drilling of test holes on a scale involving the expenditure of thousands of dollars. The end is inevitable. It is that which invariably follows every ill-advised enterprise in which ascertained facts are ignored. The disappointment may be all the keener when the promoters realize that the facts bearing on the case were easily ascertainable.

The highest living authority on the distribution of oil and gas, the man who has done more than any one else for the successful and profitable development of all the interests related to these two products, declares that the most valuable service which science has been able to render in this connection has been the determination of the fields wherein exploration is hopeless. Iowans will do well to remember that, even in a state as munificently endowed as theirs, there are some things and some favoring conditions which Nature has failed to provide, there are some drafts on Nature's apparently limitless bounty which must go unhonored, there are some enterprises looking to the development of natural resources which in the very condition and structure of things are absolutely hopeless. Let them rather reserve all of their capital and energies for the development of the splendid resources which do exist and not waste any in the useless search for geological products which all enlightened experience shows could not, by any known possibility, be developed in the state.

EDITORIAL COMMENT.

Museum Catalogues.—Two catalogues of museums lie on our table, the first by Prof. Renevier, and the second from the Smithsonian Institution, which illustrate among other things the difference in the support to Science which is afforded in Switzerland and the U. S. respectively. The first is entitled "*Notice sur l'origine et l'installation du Musee geologique de Lausanne.* (*Lausanne,* 1895.) *Par Prof. E. Renevier.*

In spite of its title but little more than half a page is devoted to the origin and installation of the collections. The remaining ten pages are dedicated to a description of the collections and their classification. The collection is not a large one, but some points are of interest.

Room I. The *first* collection is of general stratigraphy. three glass cases exposing the principal classic fossils from the earliest to the Cretacic.

The *second* is the petrogenic collection of 1,500 specimens intended to teach the mode of formation of the rocks which compose the terrestrial crust on a system of Prof. Renevier's as follows:

a) *Deutocogenic* rocks of sedimentary origin by mechanical means.

b) *Organogenic* rocks of sedimentary origin through organic processes.

c) *Hydatogenic* rocks, of chemical origin by means of water.

d) *Pyrogenic* rocks of chemical origin by means of heat.

e) *Crystogenic* or crystalline rocks of doubtful origin on account of their crystallization.

The subdivisions of these groups are, as far as possible, equally based upon their mode of formation.

The *third* division is of the Cretacic fossils of the country.

The *fourth* is the Geotechnical collection, including ornamental marble, slate, etc.

The *fifth* is the Morphological collection (Erosion, actual consolidation, organic perforation, etc.

The *sixth* is of geological maps, profiles, photographs etc.

Room II. The hall of regional geology (collections of the western Alps and of the Southern Jura), etc.

III. Paleontology (Fossil mammals; Birds, Reptiles and Fishes, etc.

IV. Mineralogical hall, etc.

This is an unusal arrangement, especially that of the first division with its miscellaneous department at the end.

Far different is Curator Merrill's "*Guide to the study of the collections in the Section of applied Geology.*"

The non-metallic Minerals by George P. Merrill. (From the report of the Smithsonian Institution for 1899, pp. 155 to 483 with thirty plates. "Washington. Government printing office, 1901."

The 328 pages of this useful catalogue interspersed with plates and cuts follow the general classification of Dana in general in the groups which are I. The Elements. II. Sulphides and arsenides. III. Halides. IV. Oxides. V. Carbonates. IV. Silicates. VII. Niobates and Tantalates. VIII. Phosphates. IX. Nitrates. X. Borates. XI. Uranates. XII. Sulphates. XIII. Hydro-carbon compounds. XIV. Miscellaneous.

Under these latter it is to be regretted that the Mineral Waters are stowed, as if in the way. They deserve a separate chapter like the rest. The lack of a proper bibliography of mineral waters of the United States was felt when Daubrée was writing his great work on Les Eaux Souterraines; and sought in vain for systematic information on the subject in this country. Little more than the advertising sheets of rival mineral springs with analyses by known and unknown persons—principally physicians or druggists of the immediate neighborhood, could be obtained.

The catalogue of the XIII sections is admirably full and contains besides the American and principal foreign localities. of each particular product, a very useful bibliography.

P. F.

CONTRIBUTIONS TO THE LITERATURE OF VOLCANOES.—An interesting review of the great work of Stübel on the volcanoes of Ecuador has appeared in the Bulletin of the Société Belge de Géologie de Paléontologie et d'Hydrologie, by Prof. W. Prinz, of the free University of Brussels. The title is "Les volcanoes de l'Ecuador par Alph Stübel. Resumé des theories d'interet général contenues dans cet ouvrage. par W. Prinz, Professeur à l'Université libre de Bruxelles."

He states that Stübel was of those who seek the remotest regions for new facts with which to enrich science, and that he had remained for nearly ten years in the high region of Columbia and Ecuador to study the volcanoes. His results were six thousand specimens of rocks and the aquarelles, sketches, and even oil paintings of M. Troya, an artist who accompanied him, all of which are in the ethnographic museum at Leipzig. The volume which is reviewed is intended as a descriptive catalogue of these objects. There are 14 cuts in the text and a map on a large scale 1:250,000 by M. Th. Wolf. The measurements on which the map is based are discussed by M. B. Peter of the Observatory of Leipzig.

M. Stübel after much hesitation in grouping the separate cones finally concludes that there are but 41 volcanoes in Ecuador, grouped in two chains which enclose the high plateau to the east and to the west. The object of the study is to seek the connection which still exists between the eruptive manifestations and the part of the globe yet in a state of fusion, or in other words do the modern volcanic phenomena depend on the development of the earth?

The tendency of his reasoning is to the negative, and in support he cites the enormous thickness of the crust (even where supposed to be least so.) What disproportion between the flow of lava and the supposed source! Earthquakes too are from causes not situated very deep.

The distribution of the volcanoes in Ecuador, Columbia, Bolivia, Chili, and Mexico, Central America, and the Aleutian group is very remarkable, for it is evident that a great nucleal centre would not discharge the excess of its igneous fluid by narrow channels, but by great orifices in the regions of flow, which would be kept permanently open during the eruptive period.

He leaves the same dilemma which his object was to solve. Either the earth is surrounded by a thin crust although its interior is in a state of fusion, which is in contradiction with certain geological and astronomical facts, although offering an easy explanation of volcanic action; or the earth is solid to a great depth and contains only a relatively unimportant kernel of igneous materials, which conforms to the astronomical and geological facts but leaves the eruptive phenomena unaccounted for.

P. F.

GILBERT'S SUMMARY HISTORY OF NIAGARA FALLS.

Numerous partial descriptions and discussions of Niagara river and Niagara falls have been published in late years, owing to the rapid growth of the Pleistocene geology of the region of the great lakes. Some views have not been in accord with others, and some geologists have amended their own views. The result is that those who have not closely noted the development of this history find some difficulty in forming a consistent idea of the actual result arrived at by these researches. Below is the summary of this result as given by Mr. G. K. Gilbert in connection with the new map of Niagara river and the Pan-American Exposition, dated May, 1901.

N. H. W.

"The beginning of the river is intimately associated with the Glacial or Pleistocene period. Before that time lake Erie and lake Ontario did not exist and there was a very different system of rivers in the region. In the early part of the period glaciers were formed on the highlands of Canada, and gradually grew and spread until they covered all the region of the great lakes. They eroded the land in places and deposited the eroded material elsewhere in the form of drift. Then they melted back so as to uncover the lake region, making an interglacial epoch, and afterwards they again grew large. These oscillations were several times repeated, so that the Pleistocene period was composed of several glacial epochs separated by interglacial epochs. Each interglacial epoch had its own system of lakes and rivers, and in one of these epochs a great river traversed the Niagara district, crossing the escarpment a few miles west of the mouth of the Niagara gorge. Like the Niagara, it made a gorge, and this gorge was eaten back from the neighborhood of the village of St. Davids to the position of the present Whirlpool. The readvance of the glacier not only abolished this river but filled with drift the gorge it had made, so that one may now cross it on what is known as the Old Portage road without suspecting the existence of a buried valley.

"When the ice for the last time melted from the land, it left a hollow which we know as the basin of lake Erie, and another hollow which contains lake Ontario, and it left the face of the land in such shape that the overflow from one lake to the other could not follow the valley of an earlier stream but sought out a new course. Thus the Niagara river was born; and its cataract has been engaged ever since in the making of the gorge.

"Just before the establishment of lake Ontario there was a greater lake in the same basin, with an outlet to the Mohawk and Hudson rivers instead of the St. Lawrence. The abandoned shore of this greater lake, called by geologists the Iroquois beach, lies close to the escarpment and can be traced out by means of its bluffs and ridges. Its line is followed for many miles in New York by a road called the Ridge road, and this road crosses the map. At Dickersonville it runs on a typical beach ridge of gravel and sand. Near Model City it is on top of the ancient shore bluff, and in Lewiston it is on a gravel ridge which was built as a spit in the old lake.

"After the disappearance of the ice the land it had covered was gradually uplifted, the rate of rising being different in different parts. As a result of this warping of the earth the outlets of certain lakes were changed, and these changes had an important influence on Niagara river. There were two epochs during which most of the water of the great lakes region flowed to the ocean by other routes, leaving to the Niagara only the water from the lake Erie basin. During these epochs the river was much smaller than it now is, probably carrying only ne-eighth of the present amount of water, and the cataract vas then a less powerful agent of erosion. The deeper parts f the gorge, which now contain pools, were excavated by the ataract when the volume of the river was large. The shallow arts, which now contain rapids, were excavated when the volume was small.

"The determination of the age of the river, or the time which has been consumed in the making of the gorge, is a problem of great interest, to which much attention has been given. As the length of the gorge is known and as the rate at which the cataract now lengthens the gorge is known, it would seem a simple matter to compute the time. Taking the gorge length as a dividend and the annual change in length as a divisor, we obtain 7,000 as a quotient, and this has been assumed by some to represent the number of years occupied by the river in the work. But this computation fails to take account of a number of important considerations. The thickness of the limestone is not the same in all parts of the gorge; the hight of the cataract was not the same through the whole period; and, as just pointed out, the volume of the river was sometimes much less. The last-mentioned qualification is the most important of all, for the diminished river would erode much less rapidly than the full river. If we knew precisely what difference the change of volume would make, a fairly satisfactory result might be obtained, but this we do not know. The smaller of the two divisions of the cataract, known as the American fall, now contains nearly as much water as did the whole river during times of diminished drainage basin. But the crest line of the American fall has not changed its form appreciably since the year 1827, when the first accurate drawings of it were made. Its recession must be many times slower than that of the Horseshoe fall. This fact indicates that the rate of erosion of the narrowest parts of the gorge was exceedingly slow and the time consumed exceedingly long. Its estimation is little better than a guess. One may say with some confidence that 7,000 years is altogether too small an estimate of the age of the river, but whether the real age is expressible in tens of thousands or in hundreds of thousands of years is at present a matter of doubt."

THE TERM HUDSON RIVER.—Dr. Rudolf Ruedemann has reviewed the rather quixotic record of this term in geological literature in a recent publication by the New York State Museum.* He also adds many new facts relating to the geographic and stratigraphic distribution of the fossils. He proves that the Norman's Kill series of shales represents the most important part of the Hudson River series, but that its fauna is only one of four faunas which are embraced in the Hudson River rocks, and the lowest of the four. He also finds that the Norman's kill shales are in the Trenton, lying immediately on the lower Trenton limestone. His summary conclusion is as follows:

N. H. W.

"This paper purports to demonstrate the presence of four zones of shales in the 'Hudson River shales' of the Hudson valley region about Albany. These zones, which extend from N. N. E. to S. S. W., consist, going from west to east, of shales containing the Lorraine, Utica, Middle Trenton and Norman's kill graptolite faunas. The shales last named include lower Trenton conglomerate and rest on lower Trenton limestone. This succession of zones places the Norman's kill graptolite beds, which form the mass of the Hudson River shales in the Hudson river valley, between the middle and lower Trenton, and determines, together with other facts, the Lower Trenton age of these shales.

"The beds lie conformably inverted, on account of their being the remnant of the undertumed wing of an overturned fold of the Appalachian type. This fold has turned into an overthrust fault which brought the Cambric beds as the next succeeding terrane above the Norman's kill shales.

"On account of the fact that the mass of the beds hitherto called Hudson River shales and correlated with the Lorraine beds of central New York, is composed of terranes ranging from the Lorraine to the lower Trenton, and on account of a lack of a fully representative fauna and of a complete section of the Lorraine portion of these terranes, it is proposed to drop the term Hudson River shales for the uppermost part of the Lower Siluric, and the term Hudson River group for the Utica and Lorraine beds, and to employ the term Norman's Kill shales for the clastic facies of a part of the lower Trenton which is characterized by the graptolite fauna of the Norman's kill."

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* The Hudson River beds near Albany and their Taxonomic equivalents. *Bull. No. 42*, vol. viii, April, 1901.

REVIEW OF RECENT GEOLOGICAL LITERATURE.

Phylogeny *of the Rhinoceroses of Europe.* BY HENRY FAIRCHILD OSBORN. (*Bull. Am. Mus. Nat. Hist., vol.* XIII., *article* XIX., *pp.* 229-267, 1900.)

Some *New and Little Known Fossil Vertebrates.* BY J. B. HATCHER. (*Annals, Carnegie Museum, vol.* I, 1901, pl. 1-4.)

The Rhinocerotidæ have hitheto baffled the taxonomist, and their origin, development and migration are still problematic. The phylogeny proposed by Mr. Osborn divides the rhinoceroses into six phyla, having no known relation to each other. The supposed stem forms are traced back to the early Cenozoic, thereby suggesting that the rhinoceroses, like numerous other mammalian phyla, come under the law of early divergence.

Mr. Osborn bases his classification upon the proportions of the skull and correlated proportions of the body and upon the location of the horn cores. He finds these to be the main divergent characters, setting aside several homoplastic characters heretofore employed in classification.

Besides suggesting a hypothesis of descent, Mr. Osborn offers some interesting systematic and comparative descriptions, based upon the study of the collections in various European museums.

Mr. Hatcher's paper is based upon material collected by the paleontological expedition of 1900, for which Mr. Andrew Carnegie supplied the funds. He describes *Trigonias osborni*, a new genus of rhinoceros, from the base of the White River Oligocene. The manus differs from all other known American rhinoceroses in being functionally tetradactyl; it has an unreduced number of superior teeth; and simple structure of the superior premolars. It is therefore of a generalized type, and is the most primitive member of the Rhinocerotedæ at present known.

The comparison with the unreduced teeth of *Trigonias* will make possible the establishment of the homology of the teeth of the modern rhinoceroses. *Trigonias* probably represents the ancestral form of one of Mr. Osborn's six groups, the *Aceratheriinae.* I. H. O.

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CORRESPONDENCE.

ARE THE ST. JOHN PLANT BEDS CARBONIFEROUS? The writer has been urged to take notice of the opinion of Dr. David White, of the United States Geological Survey, expressed as to the age of the St. John plant beds, or "fern ledges," as they were designated by the late professor C. F. Hartt.

As long as Mr. White's statement of the age of these beds was expressed merely as an opinion based on the composition of the flora which these beds contain (which flora he regarded as that of the Pottsville conglomerate of Pennsylvania, or in English parlance the Mill stone grit*), it did not seem to call urgently for reply. But since he has lately written a communication to the Natural History Society of

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* U. S. Geol. Surv. 20th Ann. Rep. Part ii, General Geology, &c., page 917.

Montreal, wherein he has stated that the "erroneous reference of this fauna to the Devonian was forced upon Sir William [Dawson] by the findings of the stratigraphers,"† it becomes necessary for the writer to show something of the history of these "findings," since to him and to professor L. W. Bailey is chiefly due the assignment of the age required by the stratigraphy.

With this question is now involved the age of certain plant-bearing terranes in Nova Scotia, surveyed and mapped by Messrs. Hugh Fletcher and R. W. Ells, of the Canadian Geological Survey; but in this communication the writer proposes to confine himself to the New Brunswick areas, and to mention the stratigraphical points bearing on the age of the plant bed as briefly as possible.

The "Millstone grit" is well developed in New Brunswick, with floras at various points; and visibly at almost all points where its borders are exposed, is underlain by red shales and conglomerates with some Lower Carboniferous limestones. The gray rocks (Millstone grit) have been traced and surveyed by Drs. L. W. Bailey and R. W. Ells from a point about 30 miles north of St. John, eastward to the Joggins section in Nova Scotia.

The underlying red shales and conglomerate above mentioned, or to use the Pennsylvania nomenclature, the *Maunch Chunk* shale, comes within three miles of St. John on the north and an outlier is found one mile to the southeast of the city. These rocks are inclined at low angles from the pre-Carboniferous complex on which they rest, and the outlier reposes upon the contact of the Mispec and Little River terranes *unconformably*.

In the valley of the Kennebecasis and the Pettecodiac rivers (which are continuous) extending northeast from St. John about eighty miles there appear at intervals beneath the equivalent of the Maunch Chunk red shales, bodies of gray and dark gray bituminous shale (near St. John mostly gray standstones) and underlying conglomerates, that were much eroded before the deposition of the red shales, etc. These gray shales contain at various points frequent remains of *Ansimites acadica* and *Lepidodendron corrugatum*, and are the equivalent of the *Pocono*.

Down to the base of this series the sandstones are "free stones." that is they have not been filled with a secondary growth of silica between the grains; the plants in the shales retain their bitumen; the limestones are not metamorphosed and the igneous effusives contain zeolites. Below this the sandstones are strongly cemented with silica and some calcite, the shales are converted into slates, the limestones are more crystalline, and the beds are usually tilted at high angles.

The division between the rocks in these two conditions is the line of a great unconformity with discordance of dip, and usually strike as well, between the underlying and overlying measures.

The first terrane below the unconfomity is the *Mispec*—Conglomerate and red slate. As this terrane contains rolled fragments of Silurian corals the whole series below it to the horizon of these corals must have been denuded before or during its formation.

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† Can. Rec. Sci. Vol. viii, p. 277.

The next terrane is the *Little River* group which contains the plant beds of the "fern ledges." To the stratigrapher it appears absurd to speak of these being equivalent to the Pottsville conglomerate (i. e., the Millstone grit) in age.

Lest it might be thought that the reference of the plant beds of St. John to this low horizon, rests only on the writers' early determinations, supported later by Drs. L. W. Bailey and R. W. Ells, he may say that Sir William Dawson went over these sections before he wrote his classic papers and reports, wherein he referred them to the Middle Devonian. Dr. T. Sterry Hunt also spent a good part of one season in examining the southern coast region of New Brunswick with Dr. L. W. Bailey and the writer; and Dr. Selwyn when Director of the Canadian Geological Survey, went over the same ground; as he gave the imprimature of the survey report to the view above expressed, it is to be presumed that he was satisfied with the evidence in its favor.

The fact of the matter is that Mr. White has read the biology of the plant bed flora from the wrong end. A few of the ancient types of this flora (Archæopteris) were known when Rogers made the first geological survey of Pennsylvania. And since Dawson studied the flora other types have been gradually gathered from the lower horizons of the Carboniferous: *Megalopteris* for instance was found in several species in Ohio by professor Andrews from the lower coal measures, and later Lesquereux described others, gathered chiefly in the south and the Mississippi states from the equivalent of the Maunch Chunk red shale. It would appear that a number of the species of this flora survived in Pennsylvania until the time of the Pottsville conglomerate.

The reference of these plant beds to the Millstone grit reminds one of the persistency with which Lesquereux some thirty or forty years ago clung to the view that the Lignite beds of the west were of Tertiary age, whereas it has been amply shown by the marine fossils that they are Cretaceous.

Many genera of plants have a wide vertical range; witness the recent genera, Amentaceæ &c., in the Cretaceous, some species of which are very difficult to distinguish from modern forms; is the Cretaceous recent because it contains these? Some species of marine forms (Brachiopods and Trilobites even) range through a whole geological system, why may not some plants?

To recapitulate, the following changes occurred between the deposition of the St. John plant beds and the formation of the Millstone grit.

Erosion of strata to the Niagara horizon with deposition of the Mispec terrane.

Crushing and folding of the unconsolidated terranes from (and including) the Mispec downward. Extrusion of granite.

Deposition of the Albert shale and conglomerate=*Pocono.*

Erosion to the Laurentian or Fundamental complex, with deposition of red slate and conglomerate=*Maunch Chunk.*

[illegible] with [illegible]

[illegible] —[illegible] of the structure of the [illegible] Hawaiian Islands. A brief summary [illegible] Hitchcock [illegible] account of the [illegible] I am not aware [illegible] a paper in the American [illegible] by the Rev. Dr. S. E. Bishop [illegible] matters which can [illegible] facts, and especially [illegible] not trained in the specialty to which [illegible] Moreover Dr. [illegible] an amateur [illegible] who has done service [illegible] and a most worthy person individually.

[illegible] reiteration of the opinions expressed by the reverend doctor has been so prolonged that it has been suggested to me that further silence on my part might be misunderstood among geologists, and, therefore, I ask space in your Journal for a few statements, as follows:

1. The hypothetical cone described at such length by Dr. Bishop, does not, as a matter of fact, exist at Diamond Head.

2. The observations made by me and recorded in Dr. Hitchcock's paper above referred to, are sound, and can be verified by any person with good eyes, reasonable powers of observation, and a moderate familiarity with Tertiary stratigraphic geology.

3. The inferences or hypotheses which I drew from those observations are subject to the criticism of experts in Tertiary geology and will take their chances of acceptance in the usual manner.

4. The old beaches with their corals, sedentary bivalves like *Chama*, *Ostrea*, etc., and other attached invertebrates, remaining as they grew in life, extend at least two-thirds around the cone, where I traced them (and I have little doubt, entirely around it), and under the tuff and thin sheets of lava of which the lower part of the cone is composed. Every little bluff at Pearl Harbor and sections cut in sewering the city of Honolulu exhibit similar phenomena, which are probably common to the entire periphery of the island where the sea has not eaten them [illegible]. The inter-stratification is undeniable except in defiance of the [illegible] facts. But the elevation is greater toward Diamond Head and less in the opposite direction, though the difference is not very great. In the middle portions of the cone the beaches are replaced by [illegible] layers of compacted coral sand which can be seen half a [illegible] in the calcareous snowy crusts so conspicuous on the slopes. I did not visit the upper part of the cone, but it [illegible] appearances different from that lower down.

5. I [illegible] to publish anything further on this subject, in this [illegible]

I may add that very similar phenomena can be observed on the north shores of Unga and Popoff islands of the Shumagin group, Alaska, where the age is probably Oligocene. WM. H. DALL.

Smithsonian Institution, May 1, 1901.

PERSONAL AND SCIENTIFIC NEWS.

J. W. BEEDE has been appointed instructor in geology at Indiana State University, Bloomington, Ind.

DR. J. B. WOODWORTH has been appointed assistant professor of geology at Harvard University, Cambridge.

MR. WARREN UPHAM will attend the Dartmouth College Commencement, June 23 to 26, the thirtieth anniversary of his graduation.

THE CASCADE TUNNEL, by which the Great Northern railroad passes the Cascade mountains, is three miles long and is cut wholly in granite.

DR. T. C. HOPKINS, professor of geology at Syracuse University, will work on the Geological Survey of Indiana during the present summer. His work will be on the geological map of the state.

PROF. R. P. WHITFIELD has returned from several weeks stay in the Bahamas, where he secured for the American Museum of Natural History a number of remarkable specimens of corals, to be added to the magnificent series which he has obtained on previous visits to the islands and presented to the institution.

THE UNITED STATES GEOLOGICAL SURVEY HAS ISSUED a map of Niagara river and vicinity on a scale of 1 :62500, showing the topography and the culture features, which will be of great convenience to all who, visiting the Buffalo Pan-American Exposition, desire to make some examination of the geology of the region.

THE NEXT MEETING OF THE AMERICAN ASSOCIATION FOR THE ADVANCEMENT OF SCIENCE, and of the Geological Society of America, will be held at Denver, Colo., Aug. 24 to Aug. 31. C. D. Walcott is president of the Geological Society and C. R. Van Hise is vice-president in charge of the section of geology and geography of the Association.

MISS L. A. OWEN describes, in *Verhandl. des VII. internat. Geographen-Kongresses, Berlin*, 1899, the discovery of a large stone ax imbedded in the bluff on the west side of the river at Atchison, Kansas, twenty miles south of St. Joseph, Mo. The implement, whose discovery is attested by affidavit taken by an eminent attorney, was found in comparatively undisturbed loess, four feet below the surface.

[illegible]

[illegible] has lately been [illegible]

[illegible] *Minerals.* [illegible] even faster than [illegible] 1870 that the Alabama [illegible] for smelting, and now [illegible] Union as a coke-pro- [illegible] Pennsylvania and West [illegible] of the state for the calendar year [illegible] Mine Inspectors at 1,798,612 tons.

[illegible] WONDERLAND FOR 1901. [illegible] of the geysers, and other remark- [illegible] National Park, was written by [illegible] the *Western Literary Messenger*, in [illegible] He visited the park May 19 and [illegible] He was a trapper, of more than ordinary education [illegible] a civil engineer, connected with the [illegible] Company of St. Louis. He removed to Texas [illegible] near Dallas.

[illegible] UNITED STATES GEOLOGICAL SURVEY in con- [illegible] with professor Osborn's monograph on the titan- [illegible] which is the first of the new series of monographs [illegible] to be taken up, Mr. N. H. Darton, of the Sur- [illegible] accompanied by Mr. J. B. Hatcher of the Carnegie Muse- [illegible] in Pittsburg, will make a thorough investigation of [illegible] South Dakota to establish as definitely [illegible] relations of the horizons in which [illegible] been found.

[illegible] vice president, section E, [illegible] American Association for the Advance- [illegible] a plan and program [illegible] from Aug. 17 to Aug. 2 [illegible] association, [illegible] Geological S [illegible] which will be [illegible] ate of Colorado, has been arranged with the cooperation of lessrs. S. F. Emmons and Whitman Cross.

EXPLORATIONS IN ALASKA. It is reported that the United tates Geological Survey will send three expeditions to Alaska his summer. The first, under J. W. Peters, will start from ergman, nearly 1,000 miles northwest of Sitka, and proceed o the Arctic ocean. The party hopes to advance eastward as ar as the British boundary and will then turn westward again nd proceed toward point Barrow. The second party, led by W. C. Mendenhall, will work in the vicinity of Kotzebue sound. The third party, led by M. Gerdine, will continue explorations in the region of Copper river.

THE DEPARTMENT OF VERTEBRATE PALAEONTOLOGY of the American Museum of Natural History will have three parties in the field this season under the general direction of professor H. F. Osborn. One will continue the work in the Pleiocene beds of the Mt. Blanco region in Texas, where so many and such fine remains of mastodons, horses and camels have been found by the museum parties in recent years. The second party will continue the excavation of the celebrated Bone Cabin quarry in the Como district of Wyoming, while the third party will prosecute the collection of dinosaurian remains in the Black Hills region of South Dakota and Wyoming.

LEHIGH UNIVERSITY, at South Bethlehem, Pa., publishes a list of the titles of theses to be presented by candidates for degrees, June, 1901. This list gives sixty-one titles. They are almost wholly scientific. The exceptions are two, one devoted to the modern meaning of socialism and the other to Chaucer's "Prologue." Nine are in the course of mining engineering and the remainder, which is the larger half, are in some line of engineering or in chemistry. Not one is devoted to any phase of geology, nor to mineralogy nor to any question of petrography. It seems anomalous that in a mining state like Pennsylvania, whose geology has furnished many of the important elements of the science in America, a university of such scope and standing could graduate a scientific class of sixty-one without evincing any sign of geology in the final theses.

GEOLOGICAL SOCIETY OF WASHINGTON. At the meeting of this society on April 24, Mr. G. P. Merrill exhibited specimens of the so-called Moldavites from Bohemia and Moravia and gave a brief resumé of the views of various writers as to their supposed meteoric nature. He also exhibited weathered pebbles of obsidian from several localities in the arid west which showed corroded surfaces suggestively similar, and which he regarded as produced by natural temperature variations and the corrosive action of the atmosphere.

At the same meeting was exhibited a preliminary sketch for

[illegible]

[illegible] a party of nine students [illegible] Harvard [illegible] accompanied Prof. W. M. Davis [illegible] along [illegible] Pennsylvania. [illegible] Scranton via Lackawanna road, a [illegible] was made of the Triassic lowland and the [illegible] the highland hills and valleys, and the great Appalachian valley, geological maps in hand. A day was spent on the Susquehanna above Wilkesbarre, to see the meandering valley in the Alleghany plateau; and evidence of at least two cycles of erosion was found. Descending the river, a side trip was made to the coal regions, where the scenes of industrial desolation in the anthracite basins was in marked contrast with the thrifty agricultural landscape prevailing outside the Pottsville and Pocono ridges. A synclinal apex of Pocono was ascended over Herndon, on the Susquehanna, then a train ride through the five water gaps to Harrisburg. A half day was given to the extraordinary meanders of Conedoquinet creek, and a morning to the prong of Archean of South Mountain at Reading. Thence the party returned direct to New York by rail.

INCREASED COAL MINING IN PENNSYLVANIA. In 1891 the number of bituminous coal mines in operation in Pennsylvania was 705, while on January 1st, 1901, the number had increased to 943, an increase of 238, or more than twenty-five per cent. Somerset and Armstrong counties have doubled the number of their mines, and Cambria county almost so. In the past decade Allegheny has gained thirteen; Armstrong, eleven; Beaver, three; Bedford, five; Butler, three; Cambria, fifty-four; Center, twelve; Clearfield, six; Elk, nine; Fayette, thirty-two; Huntingdon, four; Indiana, sixteen; Jefferson, eleven; Somerset, thirty-four; Washington, six, and Westmoreland, twenty-six. The counties showing losses are: Blair, one; Bradford, three; Mercer, five, and Tioga, three. The remarkable increase has been greater during the priod 1899-1900 than in any other year of the decade. Captain Baird Halberstadt, of Pottsville, formerly assistant geologist of the Geological Survey of Pennsylvania, has just completed an elaborate and extremely valuable map of the bituminous coal fields of the state, showing the undeveloped and developed areas with the location of every commercial coal mine of these regions.—*Mines and Minerals.*

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Errata for Volume XXVI

On p. 309, line 9 from bottom instead of "Wachsmuth Collection" read Wachsmuth and Springer Collection.

On p. 310, line 17, instead of "statements" read statement.

Errata for Volume XXVII

On p. 258, for "Peticra" read Peltura.
" line 18, for "Ctinopyge" read Ctenopyge.
" line 22, for "Solmopleura" read Solenopleura.
" line 20, for "this" read the.

On p. 329, line 7 from the bottom, for "decomposition" read deposition.

On p. 330, line 7 from the top, for "volcanic" read vein.

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ERRATA VII

Erratum for Volume XXVII.

Page 388, line 6, for Java read Jena.

Errata for Volume XXVIII.

Page 119, line 6 from the bottom, erase the words: "by the means shown in plate V."

Page 281, line 8 from the bottom, from "reproduced" read represented.

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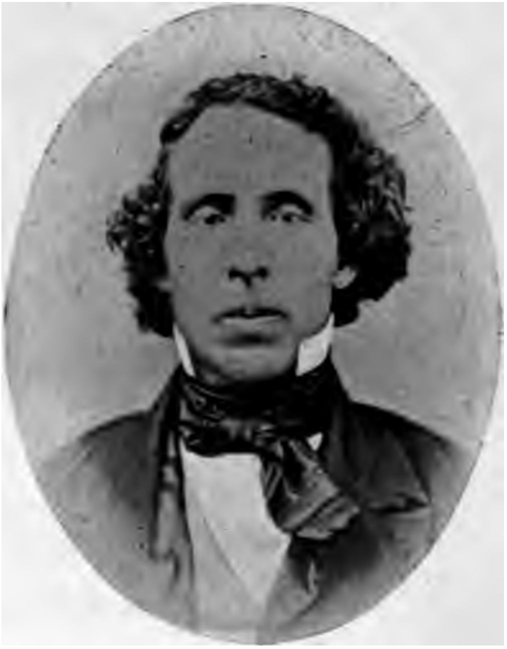

Yours Truly

The American Geologist,
Vol. XXVIII. Plate I.

AMERICAN GEOLOGIST.

VOL. XXVIII. JULY, 1901. No. 1.

SKETCH OF THE LIFE AND WORK OF AUGUSTUS WING.

By HENRY M. SEELY, Middlebury, Vermont.

PORTRAIT.

In this loving record of a portion of the life and work of the reverend Augustus Wing, the writer can scarcely proceed without at once calling attention to two facts that come incidentally into the story. The first of almost universal recognition is that the science of geology up to a very recent date has largely been wrought out by persons engaged in teaching. Their results have in the main been made possible by the wise husbandry of school vacations together with the economical use of hours between exacting class-room duties.

The preparation of an address that fellow-workers will care to remember, or of papers which they will care to read and re-read are the results of long time and labor, and these contributions represent only a fraction of what they have really accomplished. This labor of love may properly be regarded as an overflow. The field of science has been made fertile by this irrigation.

Exceptions, indeed, there are that at the same moment startle, inspire and depress, as when some favored genius sends forth in quick succession notable contributions to science. This is the exception; the rule holds. The rare occasional papers have been the revelation of thoughts and researches of well filled hours coming between lecture and lecture, or left over from other professional work.

The other fact of rarest recognition is that science may be the richer from the good service rendered by one who never made a popular address nor presented to society or editor a valuable scientific paper.

The subject of this sketch, the reverend Augustus Wing, was born at Rochester, Vermont, November 19, 1808.

We need not go far back to establish the character of the stock. James Wing, of Hardwick, Mass., the grandfather, was a member of the "Committee of Correspondence" in the early days of the American revolution. The father, also James, was a volunteer from Hardwick in the second war with Great Britain.

To the home of the first James, the grandfather, came thirteen children. The third son, the sixth of the family, named for his father, grew to early manhood in Hardwick. He was noted for great ingenuity and sturdy self-reliance, qualities much needed in those days of pioneer life. This James, with other enterprising men, found his way to Rochester, where for a little he spent his summers. When, however, the place at Rochester had in part been prepared as a home, he with his young wife, Hannah Wetherbee, in the spring of 1804, left Hardwick for a permanent place in Rochester. It was a horseback journey they had. Blazed trees marked the way to what was to be their home nest, husband and wife each carrying a fledgling perched on the saddle.

To the two sons brought from Hardwick was added the third, Augustus, at the above-mentioned date, November 19, 1808. Other children, sons and daughters came to the family, until the number in all was eleven.

The children enjoyed such school privileges as Puritan pioneers were always and early accustomed to give. The father of Augustus prized the advantages of higher schools of which he had been deprived in part, and he looked with favor on the plan of the son when he proposed to carry his studies beyond the range which the home school afforded. On the other side of the Green mountains, to the west, settlements had been made, earlier than that at Rochester; the comforts and privileges of such life had outrun those of the eastern side. High schools and academies had already been founded. So when young Augustus wished to pursue his studies further he had to cross the mountain range. A school of past and present high repute, the Burr and Burton Seminary, at Manchester, Vt., attracted him, and here with his father's approval, he entered upon college preparatory studies. In 1835 he was admitted to

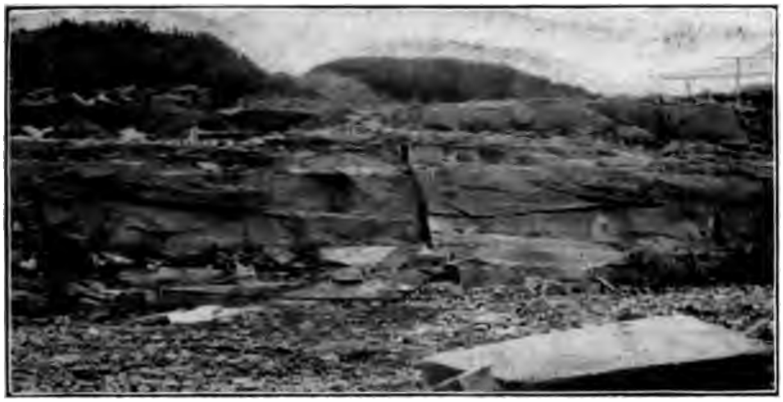

FIG. 1.—Concave parting in Medina sandstone, Slack's quarry, Holly, N. Y., Looking W. 10° N.

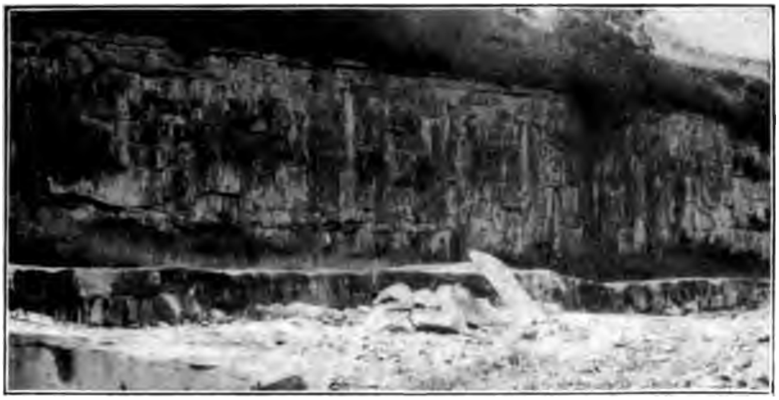

FIG. 2.—Succession of four convex partings or ridges in Medina sandstone, Old Quarry, Albion, N. Y. Looking S. W.

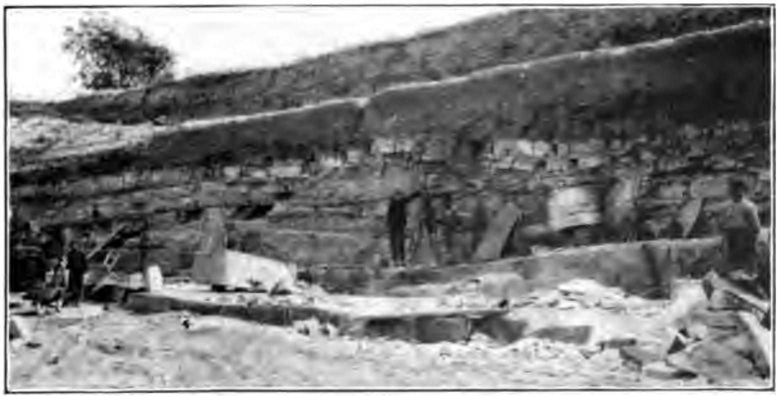

FIG. 3.—Concave partings in Medina sandstone, Horan's quarry, Medina, N. Y. Looking S. E.

"*BEACH STRUCTURES IN MEDINA SANDSTONE.*"—H. L. FAIRCHILD.

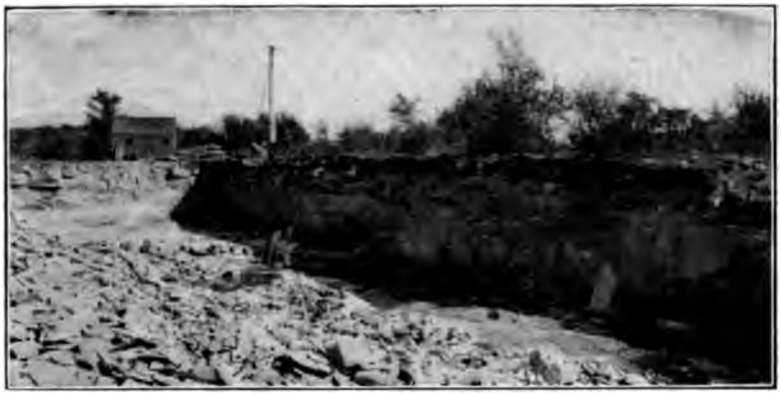

FIG. 4.—Concave parting in Medina sandstone. Squire's quarry, Hulberton, N. Y. Looking S. E.

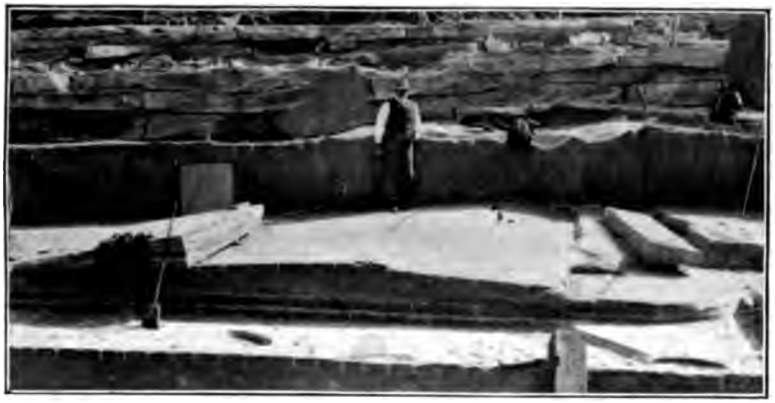

FIG. 5.—Crested ridge in Medina sandstone. McCormick's quarry, Medina, N. Y. Looking S. 15° E. (The sharp line of the ridge crest is not properly shown.)

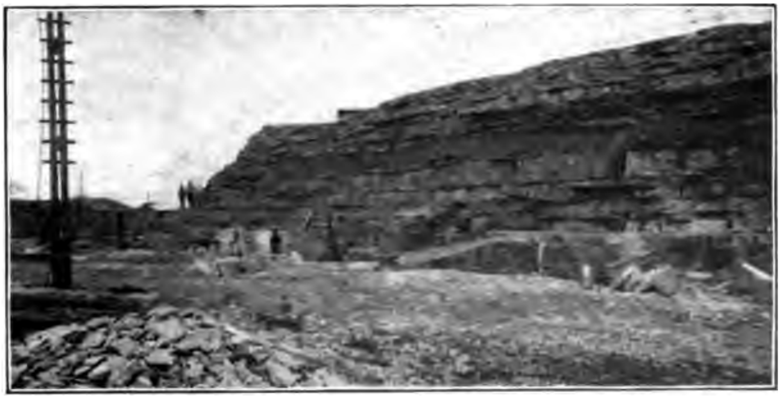

FIG. 6.—Concavity *in* Medina sandstone. Whitmore quarry. Lockport, N. Y. Looking N. 20° E.

"BEACH STRUCTURES IN MEDINA SANDSTONE."—H. L. FAIRCHILD.

Amherst College and graduated with his class in 1839. His studies were of great interest to him; mathematics, physics and the languages especially were a great delight to him. After his college graduation he went to Andover Theological Seminary, where from 1840 to 1842 he studied in preparation for the gospel ministry.

The records in the hands of the writer are too scant to permit him to speak with authority in regard to this early period of Mr. Wing's professional life; and of his ability as pastor and preacher. This, however, may be asserted: Friends, acquainted with his high attainments at Amherst and Andover, and knowing his rare mental endowments, thought him to be entering a field wide in influence and rich with the promise of usefulness. They say of his discourses, that they were logical, sympathetic, impressive and often eloquent.

But Mr. Wing's work was not to consist alone in preaching. Early in his ministry a sudden wrench, perhaps a great disappointment "where he had garnered up his heart" came to him. He stepped aside from the path that had seemed so plain, but now uncertain to him, and walked alone in another, that of teaching. Teacher and investigator he became. Not at all did he abate his interest in the studies he loved in his years of preparation. The truths of the scriptures, and the languages in which they were originally written were a source of interest to him. And so when the week day teaching was done or the week's exploration was over, he was ready to give Sunday and Bible instruction to such as were waiting for a mental and spiritual replenishment.

Academies and high schools were fortunate when they secured Mr. Wing as principal. His pupils never forgot his impressive ways of instruction. His method of teaching looked to the arousal of the highest intellectual powers of his scholars. Thought stimulated, investigation undertaken, individual judgment exercised, were in Mr. Wing's estimation of far greater value to the pupil than the acquisition of many facts from printed pages. The young people he trained never forgot their teacher. His example impressed them powerfully, and under his training they acquired an originality of investigation and an independence of thought that were of life-long value to them.

It may not be quite possible to say why a single one of the

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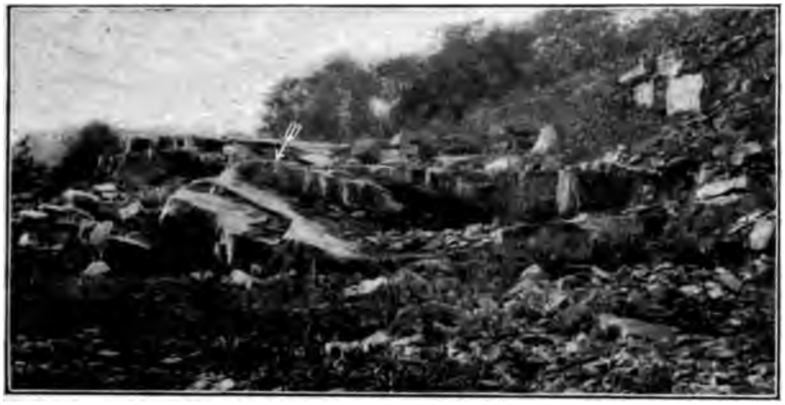

FIG. 7. Concavity and ridge in Medina sandstone. Lockport, N. Y. Looking N. W.

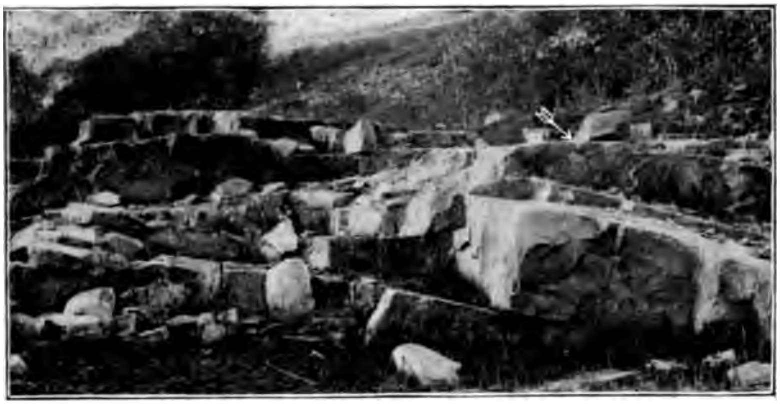

FIG. 8.—Ridge in Medina sandstone. Lockport, N. Y. Same as in Fig. 7.

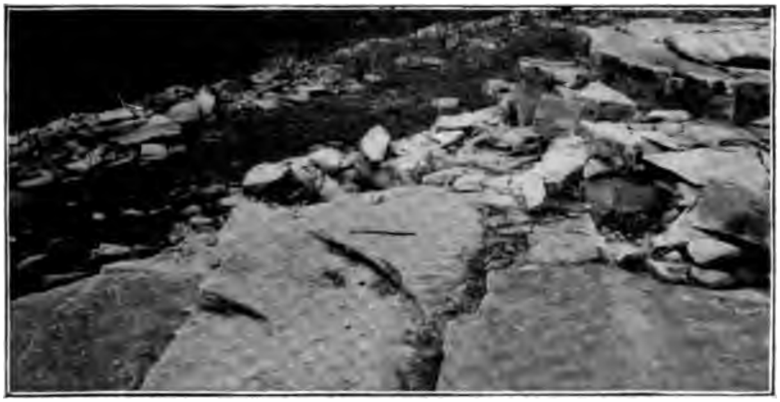

FIG. 9.—Ordinary ripples on the summit of the ridge shown in Figs. 7 and 8. The arrows in Figs. 7 and 8 point to the ripples.

"*BEACH STRUCTURES IN MEDINA* SANDSTONE."—H. L. FAIRCHILD.

The task for one of Mr. Wing's surroundings was immense. The problem was intricate and one that took years to solve. In the solution appeal must be made to the rocks themselves. It is asserted that the feet of this explorer have stood upon every square rod of exposed rock within the region of his survey. The lithological character of the rocks, their dip, their order, their fossil contents, all must be known. He carefully noted the superposition of the rocks, measured the dip with a clinometer of his own construction, and sought, with wonderfully observant eyes for traces of fossils.

The rocks of this region had been so folded, broken and worn that at first their true position was uncertain. The fossils, too, in the partly metamorphosed rocks were mostly faded and obscure; their identification difficult. But as the secret of the age of the formation must be unlocked by these fossils, this key was most carefully and in time successfully sought. Many of these fossils Mr. Wing himself determined, but for verification and in cases of doubt he turned to Mr. Billings, of the Canadian geological survey, from whom he received courteous attention and generous help.

So the search went on for years, summer and winter, holidays and vacations. Holidays gave Mr. Wing opportunity for investigating the near-by rocks, vacations afforded him time to visit far-away places in the state or in adjoining states, wherever he hoped he might get light upon his problem. It was as though he were working at a broken and tangled skein. By study of the composition of the rocks, by the use of the clinometer, but above all, by the careful comparison of fossils he disentangled the knotted, broken skein and by placing the separate threads beside each other, he arrived at a knowledge of the true relation of thread with thread; he determined the right order, the real sequence of the rocks. His problem was solved!

The problem: the age of the limestones of the Otter valley, with the associated sandstones and slates. The rocks were those designated Lower Silurian; the sandstones were the Lower and Upper Potsdam, the semi-crystalline limestone, the "Eolian" was not a single formation, but was made up of rocks of the age of the fossiliferous formations along the lake shore, now known as Beckmantown, Chazy, Black River and Trenton;

[illegible] many cases [illegible]

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[illegible] the age of those that
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[illegible] Wing when he secured the prom-
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[illegible] Blake came together on July 9, 1875.
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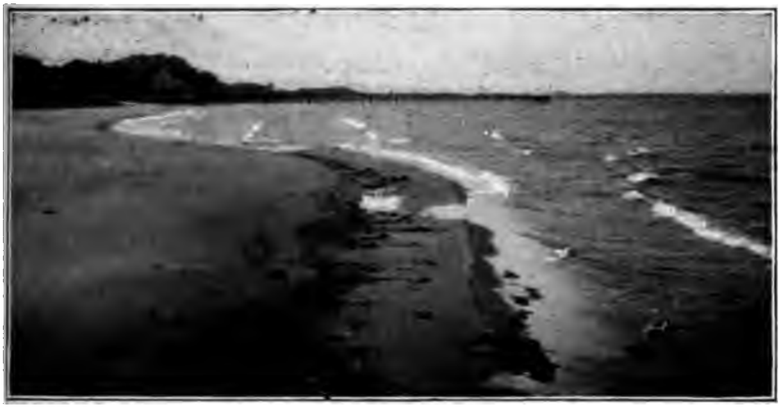

FIG. 10. Crested sand ridge on the beach of Lake Ontario. Looking W.

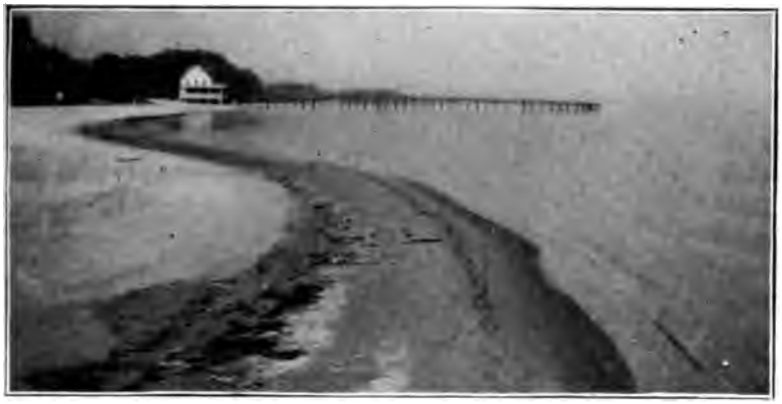

FIG. 11.—The same sand ridge as shown in Fig. 10, but the view taken a day later. The stakes mark the crestline of the previous day. The crest is now at the end of the clinometer, and not distinct in the engravings.

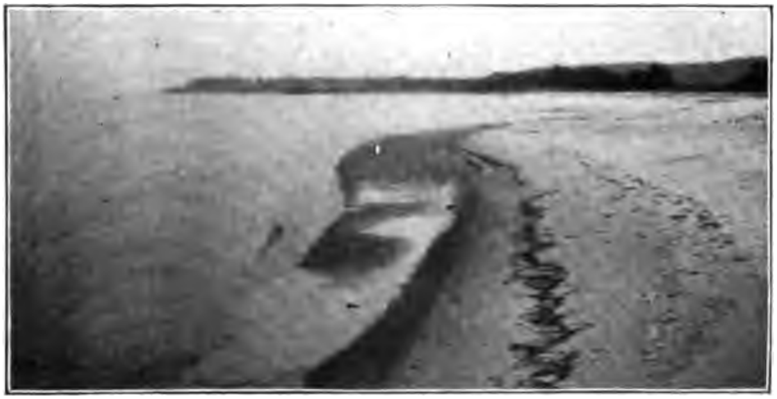

FIG. 12. The same *sand ridge as* shown in Figs. 10 and 11, but looking *eastward* at the west end.

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professor Dana and a party of geologists at Great Barrington, Mass., and there began to unfold his theory, verifying each position as they traveled through the Berkshire hills, and Hoosac valley, and made their way north, traversing the entire length of his native state, crossing and recrossing the Green mountain range, by which time his theory had given place to a deep conviction that it was correct. To Mr. Wing this, without doubt, was a moment of great triumph, when the great importance of his contribution to science was thus recognized by the highest authority in America—perhaps the highest in the world."

It is not to be asserted that all obscurities of the region, such as the relations of the lower to the upper Potsdam, the slates at the middle and southern part of the state, the exact age of the most disturbed and metamorphosed strata near the quartzyte, have been fully removed. But in the main what was to be done had been done, and Mr. Wing made good his early assertion, "That all the rocks in Addison, Rutland and Bennington counties between the great break on the west and the quartzyte on the east were Lower Silurian." The minor facts he could put over for later time, or leave indeed to others who should catch enthusiasm from the work and the success of the master.

It would have been fortunate for science if Mr. Wing could have written out his observations and discoveries. This work he fully intended to do. But he found so much in the field that, as he thought still demanded his attention, the writing was put off. He was ever finding his delight, as well as his reward, in his discoveries; so he neared his bound without having received personally the appreciative acknowledgment his fellow-workers would have gladly accorded him.

The work in the field of the season of 1875 had been severe and exhausting to him, now advancing in age, and he retired to Whiting, Vt., to accept the ministries of a sister and her family. Here this stalwart man, with large frame and great heart, with the broad intellectual range of the mature man, and yet with the simplicity of a child, of great good nature and incapable of resentment, over-flowing with enthusiasm and kindling like enthusiasm in others, came to take a needed rest.

Undiscovered truths of his loved science were beckoning him on. But there were other discoveries and other beckon-

[illegible] name [illegible]
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[illegible] gets but a glimpse of
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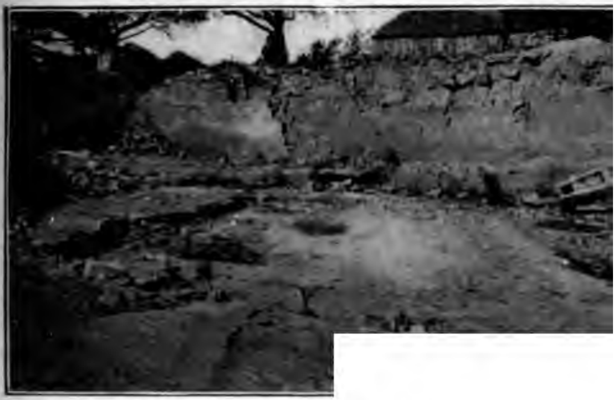

FIG. 13. Five parallel ridges in Medina sandstone. Gwynne's quarry, Murray, N. Y. Looking N. The ridges show poorly in the view on the floor of the quarry.

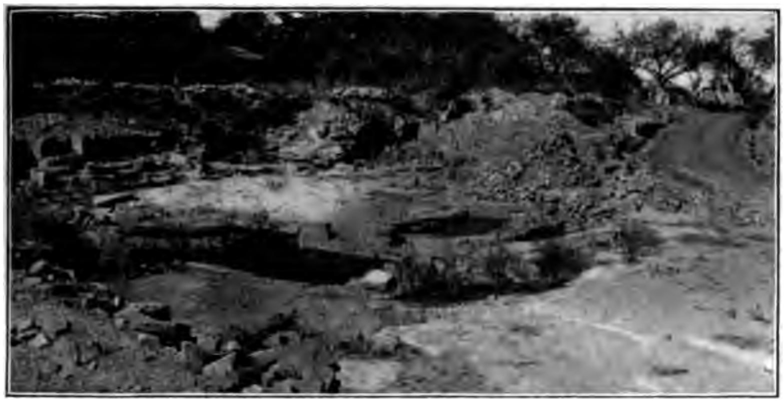

FIG. 14. Basin in Medina sandstone. Looking N. W. Near the ridges shown in Fig. 13.

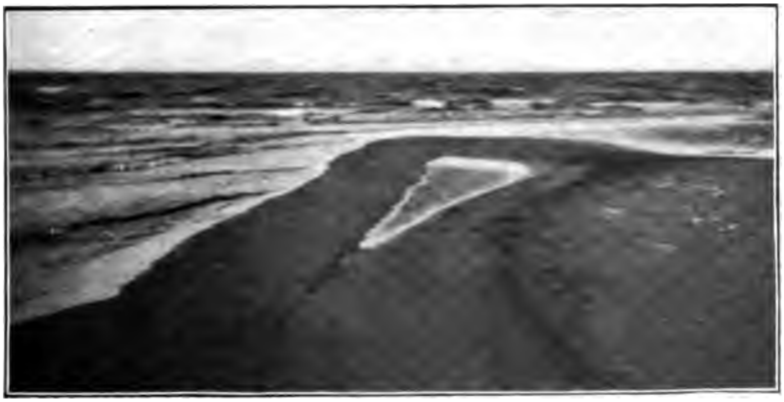

FIG. 15. *Basin between sand ridges*, beach of Lake Ontario.

"*BEACH STRUCTURES IN* MEDINA SANDSTONE."—H. L. FAIRCHILD.

BEACH STRUCTURE IN MEDINA SANDSTONE.

H. L. FAIRCHILD, Rochester, N. Y.

PLATES II-VI.

Since Dr. James Hall published, nearly sixty years ago, his "Geology of the Fourth District," the Medina sandstones of western New York have been regarded as shallow-water deposits. On pages 34 to 57 of that remarkable work he describes the markings which occur in great profusion in the sandrock and compares them with the features that he had studied on the living beach of Ontario. It is a fine example of inductive reasoning, and seemed to determine past all question the shoal-water genesis of the Medina sands. While the lower strata and the clayey beds were thought to indicate relatively deeper water, the quartzose bed, as at Lockport and Medina, were "evidences of a sandy beach which was alternately washed by the advancing and retiring waves and again left dry and above their reach."

Subsequent workers on the Medina have followed Dr. Hall's conclusions, apparently without question, until a recent paper by Dr. Gilbert, which interprets certain curving and crested structures in the sandstone as "giant ripples" formed in deep ocean.*

In examination of the Medina sandrock in numerous exposures and quarries between Rochester and Lockport the writer has found no reason for questioning its origin as beach sands, and believes that the ridges and hollows in question are typical beach structures. In this paper it is proposed to briefly state the facts and argument.

Character of the Sand Rock.

The red Medina of western New York, 1075 feet thick at Rochester, is mostly an arenaceous shale and unfit for building material. In the upper horizon, and lying at the surface in the region of Brockport, Holly, Albion, Medina, and Lockport, are thick lenses of nearly pure sandstone, in great demand for paving and buildings. Very thin laminæ of clay occur in the seams of the sandrock, particularly in the concave partings. Locally the clay may constitute definite beds or may alternate with the sand layers. The particular point is that the sand-

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* "Ripple Marks and Cross-bedding," *Bull. Geol. Soc. Amer.*, 10-135.

[illegible]

[illegible] and [illegible] water material. [illegible] and shape of the grains [illegible] [illegible] large [illegible]

[illegible]

[illegible] are the most and [illegible] [illegible] changes [illegible] characteristic [illegible]

[illegible]

[illegible] common and characteristic structure [illegible] that it [illegible] a large [illegible] in many [illegible] ings [illegible]

[illegible]

[illegible] types, the most common and [illegible] overwhelmingly abundant. [illegible] of the [illegible] irregular that [illegible] features, [illegible]

[illegible]

[illegible] which suggests [illegible] sometimes [illegible] sometimes [illegible] edges with [illegible] types are shown [illegible] types were [illegible] are [illegible] lamina [illegible] names.

The most interesting and significant of these structures are the sharp-crested ones. Examples are shown in figures 2, 5 and 8, plates II, III, IV. Figure 5 shows the one which gave to the writer the clue to their origin. The photograph does not properly show the clean, sharp, straight crestline. Nor does it show what was at first a surprise and puzzle, the clear, unmistakable wavelines that swing across the crest in varying curves. The overwash of the waves seemed inconsistent with the preservation of the sharp crestline. But this made necessary the study of the living beach, with the result that precisely similar structures were found upon the beach of lake Ontario; and the process of their construction was studied.

Figures 10-12 and 15, plates V, VI, are from photographs of such ridges on the Ontario beach at Sea Breeze, near the outlet of Irondequoit lake. Figure 10 was taken late one afternoon while the lively waves and currents were building the ridge. Figures 11 and 12 show the same ridge the next morning when the formative process had ceased. This ridge was built on the flank of a larger ridge formed a few days previous by a windstorm of greater force. Between the two ridges is a decided trough, into which in this case has been thrown the wreckage of water plants. The ridge and hollow would on cross-section illustrate those formed millions of years ago on the sand beaches of the Medina sea. This trough had a breadth of perhaps ten feet, but others formed the same day along the same shore were twenty and thirty feet wide. The breadth of the trough is, however, of little significance as the trough is only a negative or passive element and depends upon the accident of location of the second ridge with reference to the earlier ridge. The width of the same trough is also very variable. On the sea shore, with changing level of tidal waters, the ridges might sometimes lie far apart.

In figure 10 we are looking along the crested ridge in the direction of its growth as a spit. Before leaving the beach, late in the afternoon, several stakes were set at intervals exactly in the crestline. At the end of the growing spit a black post was set on the center line and at the height estimated as the average waterlevel. This post appears in figure 12. The following morning another visit was made to the place and [illegible] graphs taken, of which two are reproduced [illegible] and 12. The [illegible] lighting [illegible] the crestline, which was really [illegible] when figure 11 was taken. In figure 11 the [illegible] of the instrument [illegible] in the sand. This view shows the later effect of the waves on the older part of the ridge [illegible] shift the crestline landward a few inches, the stakes [illegible] its earlier position. Figure 12, facing the opposite [illegible] how the spit had lengthened to a crested ridge before the subsiding waves entirely ceased their action.

[illegible] of the ridge-building involves some undetermined factors, but the general process is evident. The seaward face of the ridge has the variable curve and angle produced by the glide and push of the tongues of water from the broken waves. Along the line reached by the greater number of tongues of water there is built up an irregular, sinuous crest of sand which the water pushes up on its forceful advance and leaves there as it softly retires or sinks into the thirsty sand. This line is often darkened by magnetite and garnet concentrated there, which suggests that there is a tendency to leave the heavier grains at the crest. The few stronger tongues of water which push clear over the crest do not destroy or break down or obliterate the crestline but do smooth and straighten it into a clean, sharp line, the summit of a [illegible] angle. This line is usually as direct as the embankment of which it forms the crest. Sometimes it may be apparently straight for several rods, but really makes curves of [illegible] radius.

The dimensions of these crested ridges on the Ontario [illegible] were not accurately measured. They differ greatly in size, ranging from a few inches to a few feet in height, and from a few feet to a score of feet wide at the base; with a [illegible] of a few hundred feet. It would seem that [illegible] the greater buoyancy of sea water and the greater force of [illegible] similar structures on the sea beach would often [illegible] greater size, and the intervening troughs be correspondingly broader. However, some of these structures [illegible] on the Ontario shore are comparable in dimensions as well as form with those found in the Medina sands.

At points where shoreline topography or streams produce diversion or conflict of currents the embankments may lie in different directions and may even enclose basins. Figure 15, plate VI, show such a basin at the outlet of Irondequoit, and figure 14 shows a similar basin in the Medina, where basining dip is not infrequent.

Argument against "giant ripples."

1. For troughs 30 feet across Mr. Gilbert suggests waves of the Medina sea 60 feet high. But the highest waves of the Atlantic are, according to Scoresby, only 43 feet high. On the other hand, the writer has seen troughs in the Medina sandrock up to even 80 feet across.

2. If these ridges were deep-water ripples then we should expect to find ripples of all lesser sizes down to the common form. Can any geologist report true ripples broader than three or four inches?

3. If these ridge-and-trough structures were deep-water phenomena then they should be common features in all deeper water deposits, as shales and limestones. Figure 6, plate III, shows a section in the old Whitmore quarry, north of Lockport. The absence of curving structure in the shale is apparent, while a large concavity, 40 feet across, lies in the heavy bottom stratum of sandrock. This sand stratum is the same horizon as the one containing Mr. Gilbert's ridges, shown in figures 7, 8 and 9, and is about 60 rods westward.

As "giant ripples" these ridges should occur in series or succession of uniform direction, hight and spacing. On the contrary they are usually isolated and single and in the same quarry lie in different directions. The nearest approach to a series of crested ridges that has been found is shown in figure 2, plate II. It will be seen that the ridges in this view are of diminishing size toward the right, while the larger ones at the left are rounded and without crests. These characters agree precisely with those found on the modern beach. It is only a series of diminishing size that can be formed, since a stronger storm necessary to make the larger ridge would cause the waves to override the previous smaller ridges and destroy them. The older ridge, exposed to the air and drying, soon loses its crest, if it had one, and assumes the rounded form seen in figure 2, plate II, and in figure 10, plate V.

5. The thin clay partings which occur in the seams of the hollows are inconsistent with uniform deep water conditions, but are more easily explained as beach phenomena. The muddy water often left in a trough after the storm will drop its finer material, which was held in suspension, and so produce the clayey layer.

6. The crests of the ridges are sometimes truncated, which suggests erosion of previous deposits, and implies shallow water.

7. The surfaces of the ridges sometimes bear the common small ripples, one to three inches across. Figure 9, plate IV, shows such small ripples over the crest of the ridge shown in figures 7 and 8. (The arrows placed on figures 7 and 8 point out the location of the ripples.) Their size may be estimated from the foot-rule lying beside them. The lower seams of the ridge also bear suggestion of fine rippling.

8. The ridges sometimes preserve the marks of the waves that softly glided up or over them. As described above, wave-lines showed clearly on the ridge photographed for figure 5, but are not brought out in the view. Wavelines are quite unmistakable features and their presence would seem to make the conclusion unavoidable that the deposits which hold them are beach deposits.

THE MICHIPICOTEN HURONIAN AREA.

A. B. Willmott, Sault Ste Marie, Ont.

On the northeast shore of lake Superior is a tract of about 5,000 square miles known as the "Michipicoten Mining Division." Originally set apart because of the discovery of gold-bearing quartz, it now promises to become of more importance by reason of its iron beds. The tracing of the iron belt during the past summer has given some better idea of the geological structure than was previously known.

The oldest rocks of the district are the greenstone schists. Some of these are undoubted lava flows, showing the characteristic elliptical structure described by Clements,* as occurring in the Crystal Falls Hemlock formation. At a number of points agglomerates are found, as at Little Gros Cap fish sta-

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*Mon. xxxvi, *U. S. Geol. Sur.* 112-124.

tion, north of Goetz lake, east of Manitowick, and elsewhere. Commoner occurrences are the various green schists, chlorite, hornblende, mica and sericite schists. Presumably all these schists are derived from lavas, basic and acidic. The dip of the schists is always nearly vertical and the strike follows closely the line of contact with the granite to be described later.

Succeeding these schists, perhaps interbedded with them, are the earliest sediments of the region. The most characteristic of these is a belt of ferruginous chert, which has been found at intervals for about sixty miles. This rock consists of banded hematite and silica with usually some residual carbonate of iron. The bands vary from one-tenth of an inch in thickness up to several inches. The silica is sometimes very like loaf-sugar; again it is like quartzyte, a chert, or a jasper. Red jasper is, however, not infrequent. The hill at the back of the Helen mine is a huge mass of siliceous carbonates. The rocks as a whole, and the mode of occurrence of the ore, are strikingly like the Lower Huronian iron formations of Marquette and Tower.

Besides the iron formation, beds of carbonaceous shales and limestones have been recognized at several points. Shale occurs interstratified with the ferruginous chert at Iron lake. Near Paint creek and at Eleanor lake it has also been found. Whether it always underlies the iron formation is undetermined, but it probably does not. The cherty limestone has been traced in a fairly continuous line from the Helen mine to the east of Parks lake, a distance of twelve miles.

Overlying these sediments is a very persistent belt of schist conglomerate. It is well exposed at the mouth of the Doré, where it was studied by Sir William Logan and described by him in the Geology of Canada*. Coleman† describes the boulders as "granites most frequently, then quartzytes or sandstones with pebbles generally small, next green schists, then felsyte schists and porphyroids, and finally a few gneisses, but none of the Laurentian type." A thin section of one of the quartzyte pebbles showed considerable carbonate, proving that it undoubtedly came from the iron formation.

This conglomerate has been traced pretty continuously for thirty-eight miles in a semicircular belt around the central

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***Geol. of Can.* 1863, pp. 53-4.

†*Bur. of Mines, Ont.* 1889, viii, pp. 164-7.

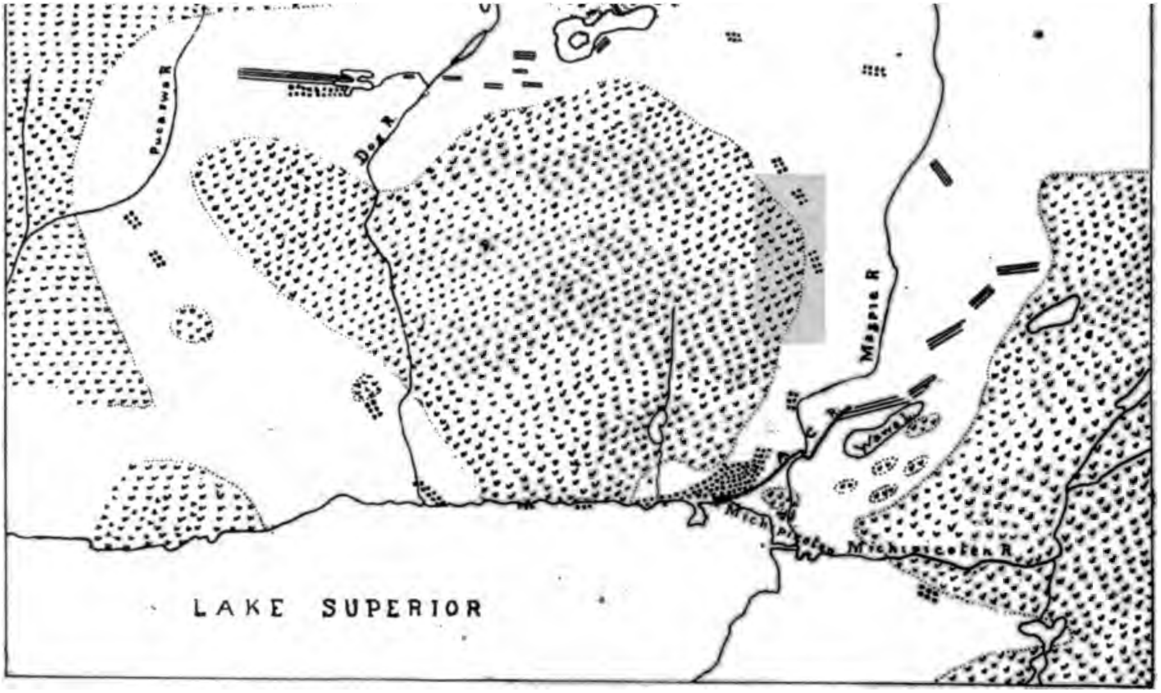
[illegible] Upper Hur[illegible]

[illegible]

[illegible] search was made for [illegible] shore of Kabenung lake [illegible] granite-gneiss [illegible] the iron forma[illegible] of the same age as the similar [illegible] north and three to the south [illegible] granite gneiss with the green schists [illegible] and in all cases the schists are [illegible] foregoing are numerous dikes of [illegible] of Keweenawan age. Other dikes [illegible] schists, are of course older.

[illegible] correct, the geological succession [illegible] shore of Superior from that [illegible] There the larger areas of granite [illegible] complex, later than the green [illegible] lowest iron-bearing formation. [illegible] gneiss, nineteen miles by twenty- [illegible] a conglomerate carrying very [illegible] Lower Huronian formation. Is [illegible] usually designated Lauren[illegible] for these reasons:—

[illegible] Bur. of Mines, Ontario, viii, p. 166.



Laurentian	Granite etc	▨
Upper Huronian	Conglomerate	▦
Lower Huronian	Banded Silica	▤
Lower Huronian	Green Schists	☐

Sketch Map of

MICHIPICOTEN

scale 8 miles = 1 inch

(1) Southeast of the Michipicoten river and reaching within nine miles of this area is an unbroken mass of granite-gneiss which extends 120 miles southeast to the original Huronian. If there is any Laurentian in the country, this must represent part of it. This Laurentian area extends six miles farther northwest in broken contact with the green schists. Three miles farther the area under discussion bears a similar relation to the same schists, though between there lies the trough filled with Lower and Upper Huronian sediments.

(2) The two areas are alike lithologically, and might well be of the same age.

(3) The large southern area is in eruptive contact with a conglomerate south of Michipicoten falls. This conglomerate has not been studied, and its age is unknown, but it cannot be earlier than Lower Huronian and is more likely Upper Huronian, as no Lower Huronian conglomerates have yet been recognized in the district. Accordingly, this Laurentian is at least post-Lower Huronian, if not later, which makes the equivalency in age of the two areas at least probable.

It will be urged that if all the granite-gneiss of the region is post-Upper Huronian there is no floor on which the early volcanic flows could be laid down. Possibly Lawson's suggestion regarding the Rainy Lake district applies here also. In both regions are masses of green schists almost vertical, surrounding a batholith of granite in eruptive contact with them. Lawson held that if the granite was the original crust on which the volcanics had been deposited, it had afterwards been refused.

At the Doré the pebbles of granite were probably derived from a mass now beneath the waters of Superior. Not only do they differ from the known exposures of granite to the north, but the cherty pebbles certainly came from a belt on the south, only a few hundred feet of which is now visible on the peninsula of Gros Cap. The way in which the conglomerate encircles the granite suggests that originally this central area was a water basin. The conglomerates surrounded the shores, and doubtless finer sediments occupied the center of the depression. The granite mass was then upheaved, and the schistosity produced in the lavas and sediments through which it extruded. In places it is now found in contact with the Upper

[illegible]

[illegible] pebbles as being from [illegible] Thessalon [illegible] Mississaga [illegible] Laurentian gneiss [illegible] pebbles of jasper are also [illegible] the Mississaga the actual [illegible] and granite-gneiss seems to be [illegible] shows a fault along the contact [illegible] explain the later consolidation [illegible] printed statement is as follows: [illegible] lake, and the mountains north [illegible] of granite and syenite; in [illegible] occasionally observable an obscure gneiss [illegible] the aspect of gneisses, so that here [illegible] Spanish river (page 1) it is very difficult [illegible] are intrusive or altered rocks."

[illegible] along a contact twelve miles east of Thessalon [illegible] "At the southeast end of lake Pakowa [illegible] there are red quartzytes, slates, and other [illegible] Huronian age, whose place in the series is [illegible] are all twisted, highly tilted [illegible] and on the southwest side of the lake [illegible] the bights of the bays and in positions behind [illegible] points and promontories, there are exposures of [illegible] massive gneiss * * * [This] makes it [illegible] probable that we have here an exhibition of a portion of [illegible] brought up against the Huronian [illegible] the accompanying atlas a fault line [illegible] five miles where the formations come [illegible] observations last summer on lake Pak[illegible]

[illegible] 1862.

[illegible]

[illegible] 812.

[illegible] 1858 [illegible]

gaming, while indecisive because of poor exposures at the critical points, confirm Murray's conclusions. Only I would explain the facts by the later consolidation of the eruptive granite-gneiss—not by a fault.

Several geologists have divided the original Huronian in two, making the break either above or below Murray's limestone band (*c*). While it is true that occasional pebbles of the limestone occur in the Upper Slate conglomerate I do not think the break is at all an important one. It is what Van Hise himself has described[*] as an intraformational conglomerate to be carefully distinguished from a true basal conglomerate. The two slate conglomerates of Murray are so much alike that they cannot be distinguished. Where the limestone band is absent, as it often is, they join, and Murray himself[†] confesses that he could not draw the dividing line. The real break, I am convinced lies at the base of the Lower Slate conglomerate and associated quartzytes. The Huronian of lake Huron is thus nearly all Upper Huronian. Logan's Huronian at Michipicoten included, however, a lower formation, characterized by its banded jasper and iron.

The succession of Michipicoten would thus be:

Keweenawan, volcanics and sediments,
Laurentian, eruptives,
Upper Huronian,
Lower Huronian, volcanics and sediments.

In this arrangement, I know that I am ignoring the conclusions founded on a supposed basal conglomerate at Thessalon described by Pumpelly and Van Hise.[‡] The evidence here does not seem to be very decisive, since Barlow[§] interprets it in an opposite manner and after a recent examination I incline to his view. Moreover, if true it is almost an isolated case against which scores of observations have been made pointing to the eruptive character of the granite-gneiss. The conclusions of Barlow[‖] in the district extending from the Mississaga to the Ottawa, seem to apply equally as well to the region from the Mississaga to the Michipicoten and beyond.

May 30, 1901.

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[*] *Prin. Pre-Camb. Geol.*, p. 723.

[†] *Rep. Geol. Sur.* 1858, p. 94.

[‡] *Am. Jour. Sci.* 1892, xliii, pp. 224-232.

[§] *Geol. Sur. Can.* x, 1897, p. 93, I and references.

[‖] Ib. pp. 59, 60, 92. I.

THE AGE OF THE KANSAN DRIFT SHEET.

By Oscar H. Hershey, Berkeley, California.

Although somewhat belated and subject to the generalizing effect of impressions dimmed by time and the vicissitudes of rough life in a mining camp, I desire to add my quota in support of the proposition that the Kansan drift sheet of the Mississippi basin is a very old one. For some years I have been in the ranks of those who maintain that the earlier glaciation of the upper Mississippi region occurred long prior to the last or Wisconsin, but it is only recently that I have come to appreciate the significance of the evidence.

The "earlier drift" of northwestern Illinois is manifestly so much older than the Iowan drift, that it was for some years correlated with the Kansan sheet of southern Iowa. Missouri and Kansas, being surrounded by impressive evidences of the aged condition of the former, I was somewhat skeptical of the existence anywhere in the Mississippi basin of a drift sheet which could be proven to be of yet greater age than it and was not inclined to approve suggestions that the old drift of northwestern Illinois was more recent than the Kansan and in fact a part of the then lately discriminated Illinoian sheet.*

In the summer of 1899, while on a pedestrian trip from Freeport in Illinois, to Mena, in Arkansas, I took occasion to visit Mr. Frank Leverett at his home in Lee county, Iowa, and he led me across the broad smooth ridge which bounds the Illinoian drift and on to the Kansan area to the west. It was in this region, I believe, that Chamberlin first recognized the significant difference in topography of the two sheets now known respectively as Illinoian and Kansan, and his interpretation has been ably supplemented by the investigations of Leverett as well as by detailed investigations by the Iowa Geological Survey. My conversion to their opinion was rapid and complete. Subsequently this was re-enforced by observations in northeastern Missouri where the Kansan drift sheet and its attendant erosion topography are typically developed.

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*A fuller discussion of this subject is contained in Mr. Leverett's report on the Illinois Glacial Lobe, forming Monograph XXXVIII of the U. S. Geol. Survey.

The Kansan ice sheet left the territory of northeastern Missouri as a remarkably even plain sloping gently toward the southeast. The pre-Kansan erosion topography was completely obscured, the valleys having been filled with drift (mainly till) to a hight greater than the rock ridges, so that the present drainage lines do not conform to the courses of preglacial streams. There were apparently no moraines or eskers to interrupt the evenness of the plain. Although this original drift plain has been mainly destroyed by subsequent sub-aerial erosion, by looking across the summits of the main divides its outline may be distinctly seen. As in the case of a dissected peneplain, in the far distance the valleys disappear from view and the country has the appearance of yet remaining undissected. It seems impossible to account for the fact that the crests of the main ridges of drift all fall into a single plane as the accidental result of the deposition of drift.

Now, the Kansan plain of northeastern Missouri has been very completely dissected. The drainage basins are long and narrow, but the valleys are dendritic in character and the topography typically that of erosion. The main valleys have been trenched to a depth of 100 to 150 feet and have broad, flat bottoms, one-fourth, one-half or not infrequently an entire mile in width. They are joined at frequent intervals by tributary valleys, the ridges between which have been reduced much below the original plain level. In fact, it is only along a few of the main divides, as that followed by the Santa Fé railroad between LaPlata and Moberly that the original plain remains practically undissected for a width of as much as one mile. It is the general degradation of the upland which is the most striking feature of post-Kansan erosion.

Railroads in crossing this area transverse to the main streams, as does the Santa Fé between LaPlata and the Des Moines river, only reach the level of the original plain at rare intervals. For three, five, or in places ten miles, in passing from one main divide across a basin to another high ridge, they are much below the level of the upland. Probably one-half of the material between the level of the main valley bottoms and the original plain, a vertical interval in some sections of 150 feet, has been removed by erosion. In short, in terms of the geomorphologists, the topography may be said to be comparatively old, for the valleys occupy a large part of the surface, are of the basin type, and most of the ridges have been reduced much below the original level.

Where the Illinoian ice sheet left the surface as a gently-sloping till plain as in western Illinois and southeastern Iowa we find a distinctly different type of topography. Valleys are fairly numerous and in places 100 or 200 feet deep, but they are of the cañon type rather than of the basin type so characteristic of the Kansan areas. Much of the surface has been reduced but little below its original plain level and the railroads in crossing Illinoian areas transverse to the main drainage lines are most of the time on the plain so that the passenger may leisurely study the upland country while on the Kansan areas, as already mentioned, he catches but a fleeting glimpse of the old plain level as the train crosses a main divide. Surely this difference means something. Probably of the total amount of the Illinoian drift between the level of the main valley bottoms and the original plain there has been removed by erosion no more than one-tenth or at most one-fifth.

Where the Illinoian and Kansan areas adjoin as in Lee county, Iowa, the contrast in topography is great. The very thoroughly dissected and much eroded Kansan drift is overlooked by a broad ridge of Illinoian drift, whose comparatively steep slopes, if exposed to erosion as long as has been the former district, should be deeply trenched by valleys; indeed, the moraine should be nearly destroyed. For about one mile, just outside or west of the moraine, the Kansan erosion topography is mostly obscured, being buried under a sheet of silty material of Illinoian age. It is here evident that the Kansan area had largely received its present old erosion topography before the Illinoian drift was deposited on it.

In southeastern Iowa the streams in the Kansan area did not cut down to so great depth as in Missouri, the larger pre-Illinoian valleys apparently having had a depth of only 50 or 60 feet, though they had a width of one or two miles. On page 106 of his admirable monograph on the "Illinois Glacial Lobe," Mr. Leverett says: "In the district occupied by the Kansan the erosion is so great that only narrow remnants of the original drift plain are preserved, along the water partings. But in the district occupied by the Illinoian more than half of the riginal drift plain is preserved, and that, too, on the imme-liate borders of the Mississippi where conditions for erosion re more favorable than in the area to the west which is occu-ied by the eroded Kansan sheet. The great contrast in mount of erosion supports strongly the view that a longer in-erval elapsed between the Kansan and Illinoian glaciations than between the Illinoian and the present time." To one who has given any attention to erosion studies in the district referred to the above conclusion appears quite conservative.

In situations such as these old drift plains, the Wisconsin drift sheet has suffered practically no erosion, and the Iowan also very little. These two sheets are, therefore, very, very recent as compared with the older. In northwestern Illinois where the country was hilly after the deposition of the drift, there is abundant evidence that the Illinoian or earlier sheet is much older than the Iowan, but if it were so old as the Kansan it must have been almost completely destroyed by erosion. The eskers show great erosion, yet if of Kansan age they should be reduced to low rounded mounds instead of the sharp peaks which they present. I think as a result of these comparative studies that there can be little doubt of the *Illinoian* age of the drift in northwestern Illinois formerly known as *Kansan*.

There is another phase of the subject to which I wish to call attention as it is a matter which I believe has not yet been discussed by anyone: As the evidence shows that the Kansan drift sheet is very much older than the Illinoian and later sheets, it may be suspected that it is even of greater age than the Quaternary era as the term is usually understood. The erosion effected on the Kansan drift plain is as great as many have been willing to credit as the capability of the entire Quaternary era.

In passing off of the Kansan drift on to the unglaciated area of southern Missouri, I was surprised to find that the type of the erosion topography did not materially change. Where the tilting of the original plain surface was slight and the streams did not cut down deeper than in northern Missouri, the valleys had the same shape and about the same amount of the plain remained. In the vicinity of Tipton, along the main divide between the Missouri and Osage rivers, there is a flat plain of greater width than that at Moberly in northern Missouri. It is rounded on either hand by more deeply trenched valleys than those in the neighborhood of the Moberly plain.

In general, I should say that under like conditions as to stream gradient, the valleys of southern Missouri are about twice as large as those of northern Missouri. Of course, the Ozark region has been abnormally uplifted and in a large portion of it erosion trenches are much deeper than in any part of northern Missouri, but where conditions have been essentially alike (except for material eroded) there is far from as great difference in excavation accomplished as we should expect except under our previous conceptions of the age of the Kansan drift sheet.

If we compare the valleys of northern Missouri with that portion only of the valleys south of the Missouri river which is below the supposed Lafayette base level,* it will appear that there is scarcely any difference in the amount of material removed by streams of an equal size and an equal gradient: if there is any difference it is in favor of the post-Kansan valleys of the drift area. However, we must remember that the valleys of one region are carved almost exclusively in drift and in the other in solid rock. There are many places in the glaciated area where the difference in power of resistance to erosion of ordinary till and such rock as commonly occurs in the Mississippi basin may be observed. The ratio is not less than as 1 :5. It is therefore certain that the valleys of northern Missouri have not been exposed to erosion as long as the post-Lafayette valleys of southern Missouri, and we have no reason for carrying the age of the Kansan drift back into the Tertiary era. Indeed, from the relation along the boundary of the glaciated area of the drift sheet and valleys in solid rock, it appears that the latter had been eroded to largely their present extent before the Kansan epoch. There are not yet known any clear cases where this may be studied, but it is known that the rock surface under the drift of northern Missouri is very uneven and contains valleys such as the Ozarkian valleys of southern Missouri.

I have detected what I consider evidences in the Kansan area near Higginsville, about 30 miles north of the Missouri

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*"Peneplains of the Ozark Highland," *Am. Geol., Jan., 1901.*

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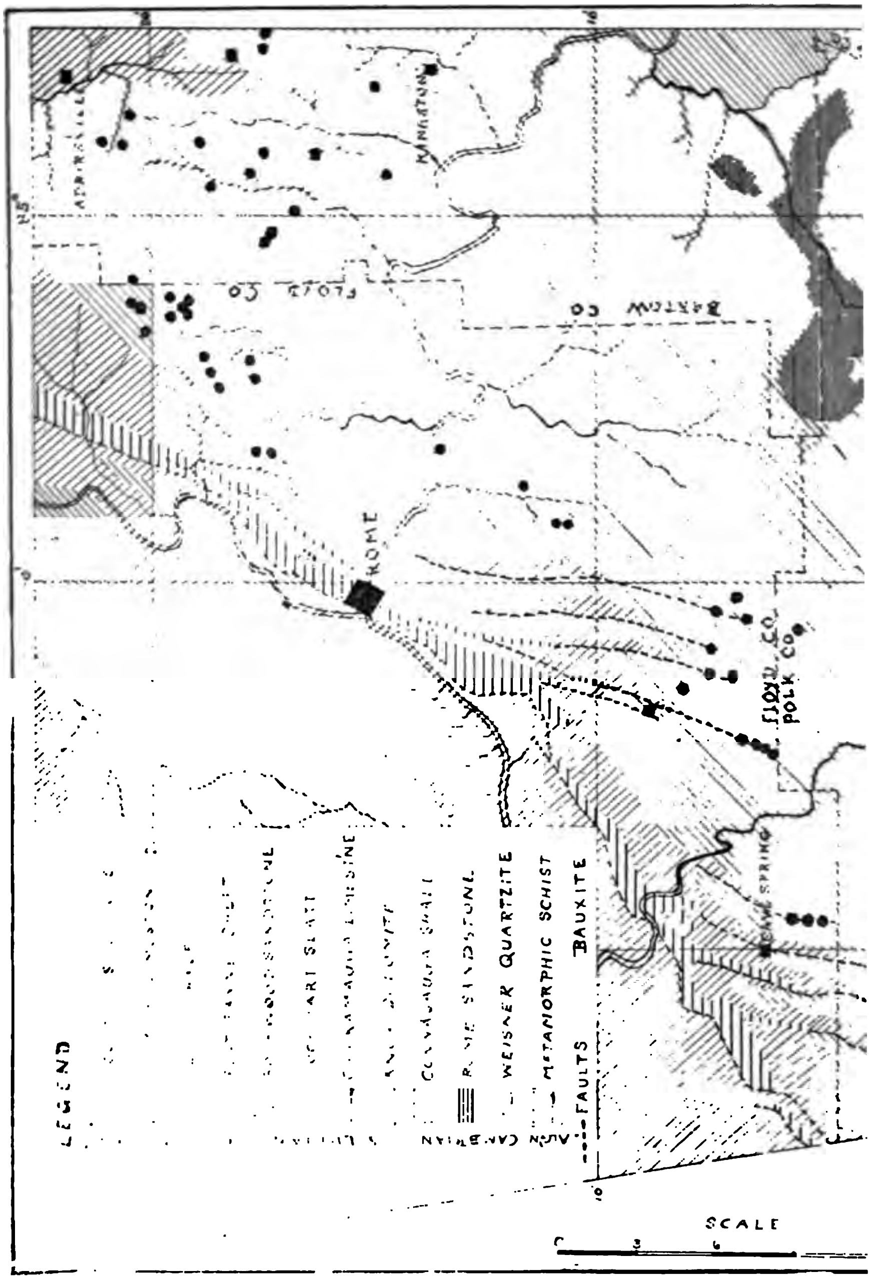
ASTOR, LENOX
[illegible]


ADAIRSVILLE
KINGSTON
FLOYD CO
BARTOW CO
ROME
FLOYD CO
POLK CO
CAVE SPRING
LEGEND
CHICKAMAUGA LIMESTONE
KNOX DOLOMITE
CONASAUGA SHALE
ROME SANDSTONE
WEISNER QUARTZITE
METAMORPHIC SCHIST
BAUXITE
FAULTS
CAMBRIAN
SCALE
0
3
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river, of remnants of the Lafayette formation under the drift. If the identification prove correct, the Kansan drift will thus be demonstrated to be newer than the Lafayette formation. True, it has by many glacialists been so considered for years, but it is hardly proven. The evidence drawn from the valleys as given above is as yet the strongest which can be adduced.

My present impression is that between the close of the Lafayette epoch and opening of the Kansan glaciation of the Missouri region, the cañon valleys of southern Missouri had been eroded to nearly their present size and that while the great post-Kansan denudation was being accomplished on the drift plain at the north, erosion south of the Missouri river was confined chiefly to a widening of the cañon valleys which, while relatively small as measured in material removed, was yet large as measured in time occupied.

In conclusion, I submit the proposition that while the Kansan epoch is probably post-Tertiary in taxonomic position, recent erosion studies on the Kansan drift areas cut sadly into that supposed long preglacial portion of the Quaternary era designated the "Ozarkian sub-period" and when the still earlier drift sheets have been correctly placed in the time scale, there may be little left of it.

Berkeley, Cal., Feb. 2, 1901.

THE GEORGIA BAUXITE DEPOSITS; THEIR CHEMICAL CONSTITUTION AND GENESIS.*

By Thomas Leonard Watson, Geol. Survey of Georgia, Atlanta.

PLATE VII.

Introduction: As the heading implies, the object of this paper is to explain the chemical constitution and genesis of the bauxite deposits of the Coosa valley region of Georgia and Alabama. The discovery of bauxite in 1887,† a few miles northeast of Rome in Floyd county, Georgia, was the first account of this mineral found in the United States. The first shipments of the ore were made in 1888, and the entire home consumption of bauxite in the United States has been, since 1890, from the Coosa valley deposits in Georgia and Alabama. Although commercial deposits of the ore have been known in

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†Nichols, Edward, An Aluminum Ore, *Trans. Amer. Inst. Min. Eng.*, 1887, vol. xvi, p. 105.

Arkansas since 1891.* practically no shipments have yet been made, though active preparations are now under way for a large output in the near future. The mode of occurrence and genesis of the deposits in the Georgia-Alabama and Arkansas districts are entirely different.†

The Georgia-Alabama deposits have been studied in considerable detail by Spencer.‡ Hayes, and McCalley,§ and theories to explain their origin have been independently advanced by Spencer and Hayes, which differ greatly from each other. While the writer's views concerning the Georgia-Alabama bauxite region are essentially the same as those stated by Dr. Hayes, the data and conclusions in this paper are based primarily on a detailed field study of the same region during 1899.

Since the physical conditions of the bauxite, including form and mode of occurrence, and the intimate relationship in the distribution of the deposits to the structural features of the region are important factors, which bear directly on the genesis of the ore bodies, it is necessary to first briefly review the general geological conditions of the area, embracing a general description of the ore and its manner of occurrence.

RÉSUMÉ OF THE GEOLOGY OF THE BAUXITE AREA.

The distribution of the ore-bodies is shown on the accompanying map (Plate VII.) As there shown, the deposits are found within a narrow belt of country, extending from Adairsville, Georgia, southwestward into Alabama. A few scattered deposits occur outside the limits of this belt near Calhoun in Gordon county, and in the vicinity of Summerville in Chattoo-

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*BRANNER, JOHN C., Bauxite in Arkansas, *American Geologist*, 1891, vol. vii, pp. 181-183.

Ibid, The Bauxite Deposits of Arkansas, *Jour. Geol.*, 1897, vol. v.

WILLIAMS, J. FRANCIS, Igneous Rocks of Arkansas, Arkansas Geol. Survey, Annual Report for 1890, vol. ii.

†HAYES, C. WILLARD, The Arkansas Bauxite Deposits, U. S. Geol. Survey (in press.)

‡SPENCER, J. W., The Paleozoic Group. The Geology of Ten Counties of Northwestern Georgia, *Geological Survey of Georgia*, Atlanta, 1893.

HAYES, C. WILLARD, The Geological Relations of the Southern Appalachian Bauxite Deposits, *Trans. Amer. Inst. Min. Engrs.*, 1894, February, Virginia Beach Meeting. Author's Edition, 12 pp.

Ibid, Bauxite, *Sixteenth Annual Report U. S. Geol. Survey*, 1895, Part iii, pp. 547-597.

§MCCALLEY, HENRY, Alabama Bauxite, Proc. Ala. Industrial and Sci. Soc. 1893.

Ibid, Report on the Valley Regions of Alabama, Part. II, On the Coosa Valley Region of Alabama, *Geol. Survey of Alabama*, 1897.

ga and Walker counties, Georgia. The above belt forms a part of the well known Coosa valley region in Georgia and Alabama. The ore has been mined at various points within this belt in both states.

The area in question forms a part of the southern extension of the Appalachian valley province. When viewed in detail it is composed of numerous subordinate valleys separated by more or less extensive parallel ridges, whose axial directions are coincident with the general trend of the valley province. This ridge-valley type of topography is definitely related to the rock structure of the area. The ridges mark the lines of more resistant rock, while the valleys are etched out of the soft shales and limestones. The ridges further mark the remnants of at least three rather distinct base-leveled plains, which are believed to have a direct bearing on the age relationship of the deposits, discussed elsewhere.[*]

In addition to the folds of the usual Appalachian type the region is characterized by two series of faults with which the bauxite distribution is very intimately associated (see map plate VII). The two types of faults are designated by Hayes[†] as (*a*) major thrust faults, and (*b*) minor thrust faults. The major thrust faults are characterized by great horizontal displacement and low inclination of the fault plane. Three faults of this type have been recognized and described by Hayes in this area, namely, the Coosa, Rome and Cartersville faults.

The minor thrust faults are very common in the southern part of the area and are of the ordinary Appalachian type. They have an approximate north-south direction, intersecting the main axis of the region at angles of 30° to 40°, and are characterized by rather steep inclinations of the plane, 40° or thereabouts. They vary in length from three to eight miles and cut the strata, at close intervals, into narrow strips forming monoclinals, which dip steeply toward the east. For the reason that the two types of faults are seldom found intersecting each other the faulting is inferred to belong to different and therefore distinct periods of disturbance.

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[*] Hayes, C. Willard, Op. cit pp. 551-554.

[†] Ibid. The Overthrust Faults of the Southern Appalachians, *Bulletin, Geol. Soc. Amer.*, 1891, vol. ii, pp. 141-154.

Ibid, Geology of a Portion of the Coosa Valley in Georgia and Alabama, *Bulletin, Geol. Soc. Amer.*, 1894, Vol. 5, pp. 465-480.

stone. The silica is distributed through the limestone in the form of segregated nodules and lenses of chert. The limestone yields upon weathering a highly siliceous clay, and the residual mantle attains considerable thickness over the entire region, leaving only scant outcrops of the fresh limestone exposed to view. The Connasauga shale (Cambrian) is next below the Knox dolomyte with an approximate thickness of 2,000 to 3,000 feet. The shales belong essentially to the aluminous type, containing as shown by analyses 20 to 30 per cent. of alumina. (See page 43.)

In the Georgia area the ore-bodies are confined principally to the Knox dolomyte and appear not limited to any particular or definite horizon in the formation, but are rather associated with all parts of it, and have therefore a somewhat wide stratigraphic range. So far as mining operations extend the Georgia bodies are inclosed in the heavy mantle of siliceous residual clays derived from the Knox dolomyte. For reasons subsequently given in this paper, the bauxite is shown not to be a residual product, as the previous sentence might imply, but its origin has been entirely different from that of the residual clays.

Associated Minerals.

The trihydrate of aluminum, gibbsite, and the silicates, halloysite and clay or kaolin, are intimately associated with the bauxite. Gibbsite is found in many of the deposits amounting to scarcely more than traceable quantities, incrusting or lining the cavities of the bauxite, not exceeding one-eighth of an inch in thickness and is readily recognized by its mode of occurrence. Halloysite is a more frequent associate than gibbsite, and occurs in the form of hard, pure white, procellaneous small nodules and lenses, irregularly distributed through the ore-bodies. It is oftentimes striated and slickensided from subsequent movement probably due to settling of the deposits. Vari-colored white to red mottled clay or kaolin is always found in large quantity inclosing the ore-bodies, and in the form of clay horses and dikes cutting the bodies in various directions and attitudes. The pisolitic structure of the bauxite passes by imperceptible gradations into the surrounding masses of structureless bauxitic clays and kaolins.

Besides gibbsite, halloysite and kaolin, commercial deposits of brown iron ore and manganese oxides, mostly psilomelane and pyrolusite perhaps, are more or less intimately associated with the bauxite deposits and have been extensively mined in several localities. The deposits of brown iron ore and bauxite are found in direct contact with each other at several localities in the district.

Chemical Composition.

While scores of reliable commercial analyses of the Georgia bauxite are available, very little has been done toward working out the exact chemical constitution of this material or attempting to establish the exact form in which it exists chemically. It has been generally assumed that the southern Appalachian bauxites, like most of the foreign material, correspond to the formula $Al_2O_3.2H_2O$, the bi-hydrate of alumina. That the assumption, however, is not warranted by the facts is evident from (1) the easier solubility of the Georgia-Alabama bauxite than that of the French ores; and (2) the uniformly lower percentage of Al_2O_3 and the proportionately higher percentage of combined water in the Georgia-Alabama ore than in the French ores, as shown in the comparison of a large number of analyses of the ore from the two countries. This is made the more apparent from the somewhat lengthy discussion which follows below.

At present, three recognized hydrates of alumina occur in nature, namely, the monohydrate, $Al_2O_3.H_2O$, known as the mineral diaspore and containing,

Al_2O_3	85.0%
H_2O	15.0%

the dihydrate, $Al_2O_3.2H_2O$, which is the general formula* given for the mineral bauxite, containing,

Al_2O_3	73.9%
H_2O	26.1%

and the trihydrate, $Al_2O_3.3H_2O$, known as the minerals hydrargillite and gibbsite, and containing,

Al_2O_3	65.4%
H_2O	34.6%

Roscoe and Schorlemmer† give the formula $(Al,Fe)_2O(OH)_4$ for bauxite, but this seems not to apply to the Georgia-

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*Dana, E. S., A System of Mineralogy, 1893, Sixth edition, p. 251.

†A Treatise on Chemistry, vol. i, p. 444.

Alabama material. Phillips and Hancock* conclude, after a chemical investigation of the Georgia-Alabama bauxite, based on the solubility of the contained alumina in different strengths of sulphuric acid, that it consists of a mixture of the trihydrate, $Al_2(OH)_6$ with clay, and probably a lower hydrate, $Al_2O_3.2H_2O$. The trihydrate is the base or the essential part. In the reports issued by the United States Geological Survey on the Mineral Resources of the United States, the mineral bauxite is referred to as the trihydrate. In his report "On the Coosa Valley Region of Alabama," Henry McCalley† refers to the Alabama mineral as the trihydrate. After a study of hundreds of analyses of the French bauxites Laur‡ makes the following statement concerning their chemical constitution:

"When these minerals [bauxites] are studied, not in isolated specimens but in mass, it is quickly noticed that there is in their composition one constant, so to speak, namely, the general proportion of anhydrous alumina, Al_2O_3, the average of which is about 66 to 69 per cent. This figure is given by the analyses of thousands of shipments. Representing this constant by A, we find three variable elements, e. besides, namely, water, silica, and ferric oxide; and it is a remarkable fact, that the sum of the weights of these is constant also at about 27 per cent. We will represent it by Pe."

"Finally, the various accessory substances (titanium, vanadium, etc.) which occur even in the purest bauxites, present a constant total of about 3 to 4 per cent. These we represent by C."

"Thus, the centesimal formula of the bauxites: 68 to 70 Al_2O_3 27(SiO_2, Fe_2O_3, H_2O)·4(sundry accessories) may be written in general form as A·Pe-C."

"But the three variable elements of Pe have the singular property of replacing one another, in whole or in part, separately increasing, diminishing, or totally disappearing, without change of the total of 27 per cent., and without altering the fixed mineral species, which is, according to our view, the bihydrate of alumina, forming the base of the mineral. These varying substitutions give rise to the different types * * *"

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*The Commercial Analyses of Bauxite, *Jour. Amer. Chem. Soc.*, 1898, vol xx, p. 211

†*Geological Survey of Alabama*, 1897, pp. 79-84.

‡The Bauxites: A Study of a New Mineralogical Family, *Trans Amer. Inst. Min. Engrs.*, Virginia Beach Meeting, February, 1894. (Author's edition, 9 pp.)

Continuing, Laur distinguishes four types of bauxite whose farmulæ are given as follows:

(1) Mixed bauxite of Baux, A+Pe........................ $\left\{\begin{array}{l}\frac{1}{3}\,H_2O\\ \frac{1}{3}\,SiO_2\\ \frac{1}{3}\,Fe_2O_3\end{array}\right\}+C.$

(2) Pale bauxite of Villeveyrac, A+Pe.................. $\left\{\begin{array}{l}\frac{1}{2}\,H_2O\\ \frac{1}{2}\,SiO_2\end{array}\right\}+C.$

(3) Red bauxite of the Var, A+Pe........................ $\left\{\begin{array}{l}\frac{1}{2}\,H_2O\\ \frac{1}{2}\,Fe_2O_3\end{array}\right\}+C.$

(4) Pure bauxite of Alabama, A+Pe...................... $[\,2\,H_2O\,]+C.$

An abstract in the Chemisches Centralblatt for 1892, page 14, of an inaugural dissertation by A. Liebreich in which an account of the derivation of bauxite from basalt with special reference to the German deposits is given, says, "chemical analyses show certain differences in the composition of bauxite from different places, the smaller amount of water in the French bauxite referring it to diaspore, while the Vogelsberg mineral is probably gibbsite (hydrargillite) [the trihydrate of alumina]."*

The writer has gotten together as many authentic analyses of the Georgia bauxites as possible, and from them the ratio of Al_2O_3 to H_2O was calculated. Also the sum of the percentage amounts of the impurities SiO_2, TiO_2 and Fe_2O_3 is given. Calculations are made and given for the two types of bauxite, namely, (a) the non-ferruginous type, in which the iron enters as an impurity; and (b) the ferruginous type, in which the iron replaces a part of the aluminum. The analyses were carefully selected, and in case of the non-ferruginous type only those which gave 55 per cent. and more of Al_2O_3 were used. This minimum percentage of Al_2O_3, 55 per cent., in the non-ferruginous type is the lowest amount of Al_2O_3 indicating the purest grade of the ore. In the ferruginous type all analyses are included which show 10 per cent. and more of Fe_2O_3.

A majority of the analyses used were obtained by analytical methods which yield the soluble Al_2O_3. On a 55 per cent. Al_2O_3 basis, however, the small percentages of insoluble residues (SiO_2) indicate that the soluble Al_2O_3 is practically the equivalent of the total Al_2O_3. This conclusion is based upon a close comparison of analyses in which the soluble

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*Quoted by George P. Merrill, Guide to the Collections in the Sections of Applied Geology in the National Museum; The Non-Metallic Minerals, 1901, p. 283.

Al_2O_3 was estimated, with others in which the total Al_2O_3 was determined. Also from analyses of several samples in which both soluble and total Al_2O_3 were separately determined in the same sample.

		Per Cent.	Molecular Ratio.		
(1)[*]	Al_2O_3	58.62	.574	1.00	Ratio of Al_2O_3: H_2O is nearly 1:3 corresponding to the formula Al_2O_3. 3 H_2O.
	H_2O	31.44	1.746	3.04	
	SiO_2	4.27	9.57 per cent.		
	TiO_2	3.79			
	Fe_2O_3	1.51			
	Total	99.63			
(2)[†]	Al_2O_3	58.91	.577	1.00	Ratio of Al_2O_3: H_2O is nearly 1:3 corresponding to the formula Al_2O_3. 3 H_2O.
	H_2O	31.59	1.755	3.04	
	SiO_2	3.34	9.39 per cent.		
	TiO_2	4.18			
	Fe_2O_3	1.87			
	Total	99.89			
(3)[‡]	Al_2O_3	61.67	.604	1.00	Ratio of Al_2O_3: H_2O is nearly 1:3 corresponding to the formula Al_2O_3. 3 H_2O.
	H_2O	29.85	1.658	2.75	
	SiO_2	4.77	8.10 per cent.		
	TiO_2	2.95			
	Fe_2O_3	0.38			
	Total	99.62			
(4)[§]	Al_2O_3	60.34	.591	1.00	Ratio of Al_2O_3: H_2O is nearly 1:3 corresponding to the formula Al_2O_3. 3 H_2O.
	H_2O	30.36	1.686	2.85	
	SiO_2	4.75	8.84 per cent.		
	TiO_2	2.39			
	Fe_2O_3	1.70			
	Total	99.54			

		Per Cent.	Molecular Ratio.		
(1)	Al_2O_3	61.92	.607	1.00	Ratio of Al_2O_3: H_2O is nearly 1:3 corresponding to the formula Al_2O_3. 3 H_2O.
	H_2O	30.61	1.720	2.80	
	SiO_2	2.68	7.04 per cent.		
	TiO_2	3.54			
	Fe_2O_3	0.82			
	Total	99.57			
(Average)					
	Al_2O_3		.596	1.00	Ratio of Al_2O_3: H_2O is nearly 1:3 corresponding to the formula Al_2O_3. 3 H_2O.
	H_2O		1.709	2.89	

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[*] Average of 28 analyses, furnished by courtesy of MR. J. R. GIBBONS.

[†] Average of 20 analyses, furnished by courtesy of MR. J. H. HAWKINS.

[‡] Average of 4 analyses, furnished by courtesy of MR. B. F. A. SAYLOR.

[§] Average of 4 analyses, analyzed by H. C. WHITE, Univ. of Ga., Athens, and quoted by J. W. SPENCER, op. cited. pp. 215-220.

[‖] Average of 3 analyses, made by THOMAS L. WATSON, Lab'y, Geol. Survey of Georgia.

SiO_2	8.59 per cent.
TiO_2	
Fe_2O_3	
Total	

(Ferruginous Bauxite)*

Al_2O_3	52.94... .519	.595...1.00		Ratio of Al_2O_3: H_2O is nearly 1:3 corresponding to the formula $Al_2O_3 \cdot 3\ H_2O$.
Fe_2O_3	12.29... .076			
H_2O	28 40...1.577	..............2 65		
SiO_2	2.83	6 61 per cent.		
TiO_2	3.78			
Total	100.24			

The prevailing structure of bauxite in all known workable deposits is pisolitic. So far as the writer can determine separate analyses of the matrix and concretions or pisoliths have never been made. While it is generally true that the pisolitic structure in case of the Georgia-Alabama ore grades into a structureless material, the pisoliths or concretions are as a rule perfectly sharp and distinct from the inclosing matrix, and the two may or may not have the same chemical composition. With the view of possibly determining this the writer selected specimens of the ore in the field and carefully separated matrix and pisoliths, and separately analyzed them in the survey laboratory with the results shown below. No attempt was made at separate analyses of isolated thin layers of the pisoliths or concretions from each other, and of the layers from the inclosed powder.

	PISOLITHS			MATRIX			
	Maddox	Bobo	Warrior	Maddox	Church	Watters	Perry
Al_2O_3	52.36	57.26	52.40	64.91	46.92	63.60	48.30
H_2O (combined)	33.17	31.69	24.06	33.00	21.68	27.15	28.01
SiO_2	3.74	0.99	4.21	0.62	20.46	6.43	3.17
TiO_2	9.70	7.63	8.79	1.05	9.80	1.95	9.75
Fe_2O_3	0.76	1.89	10.44	0.28	0.28	0.28	trace
H_2O at 100° C	0.20	0.39	0.39	0.53	0.34	0 56	0 53
CaO MgO	none	none	none	none	none	none	none
Na_2O K_2O	none	none	none	none	none	none	none
Total	99.93	99.85	100.29	100.39	99.48	99.97	99.76

The above analyses suggest more uniformity in composition for the pisoliths than for the matrix; but they further indicate no decided appreciable difference in the composition of the two parts of the mineral.

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*Average of 6 analyses.

In its purest form bauxite contains more or less foreign material either chemically combined or mechanically admixed. Iron oxide present in variable amounts, ranging from a trace to percentages equal to and occasionally exceeding that of the alumina, is usually present replacing in part the alumina, and in part only as an impurity.

Titanium is invariably present ranging usually from 1 to 10 per cent. when estimated in the form of titanium dioxide. Analyses indicate that this constituent averages higher in the pisolitic ore and is lowest in the structureless bauxitic clays. The form in which the titanium exists in the ore is seemingly dependent in large measure upon the origin of the bauxite. A study of those deposits derived from basalt and similar igneous rocks indicates that the titanium occurs in the form of free oxide or as titanic iron. This is true of the Vogelsberg deposits in Germany as shown in the study of thin sections of the bauxite by A. Liebreich; and also of the Ober-Hessen deposits by Lang. Very little if any of the titanium in the Georgia deposits exists in the form of free oxide, as a microscopic examination of a large number of thin sections of the mineral failed to indicate more than a bare trace of titaniferous oxides. Separation by means of heavy solution and by elutriation confirmed the microscopic evidence.

Silica varies from a fraction of 1 per cent to several per cent. in the purest ore, and 30 to 35 per cent. in the low grade types of material, bauxitic clays and kaolins. This constituent is usually present in the form of the hydrated aluminum silicate clay, which is invariably admixed in varying proportions with the bauxite; and is also present to some extent as free silica, as shown by the microscope.

The Georgia bauxites are usually free from traces of the additional following common impurities in bauxites of many localities: lime, magnesia, phosphoric and carbonic acids and the alkalies, soda and potash.

RÉSUMÉ: From the preceding data it is clear that the formula given by Laur for the French bauxites essentially the bihydrate of alumina and applied to the Georgia-Alabama mineral is not applicable to the Georgia deposits. The average percentages of Al_2O_3 and H_2O in the best grade of the Georgia bauxite certainly correspond to the formula $Al_2O_3.3H_2O$, the trihydrate. In a majority of analyses a variable percentage of soluble Al_2O_3 in 100°C. of 50°B. sulphuric acid is found, which ranges from a fraction of 1 per cent. in the purest ore, to 40 and 45 per cent. in the associated bauxitic clays, which are shown to grade into each other. The insoluble Al_2O_3 is probably present in the form of the hydrous aluminum silicate, clay, admixed possibly as Phillips suggests with a lower hydrate of alumina. The Georgia bauxites, therefore, in their purest form, consist in most cases of a mixture whose base or essential part is the trihydrate of alumina. All gradations in which the soluble alumina ranges from about 60 per cent. to several per cent., or pure trihydrate of Al_2O_3, to bauxitic clay, corresponding to the hydrous aluminum silicate, are known.

As remarked by Liebreich, chemical analyses of the mineral from different localities show differences in chemical composition. Thus we have analyses which correspond to the three hydratesmono- di- and tri- of Al_2O_3, which strikingly illustrates the variable character of the so-called mineral bauxite.

So far as the writer can gather from the various accounts and descriptions in which analyses of bauxites from the principal localities, both foreign and American are given, much depends upon the origin, as to the chemical composition of the mineral. Al_2O_3 forms, however, in all cases, the basis; and it ranges from 55 to 85 per cent. according to locality, with corresponding variable proportions of water of chemical combination, ranging accordingly from 15 to 34 per cent. Thus, deposits of the mineral are known which correspond on analyses with the three hydrates of Al_2O_3.

While the so-called mineral bauxite corresponds in chemical composition, according to locality, to the three natural hydrates of alumina, as a rule, no resemblance in physical properties known at present is shown to the minerals diaspore (monohydrate) and gibbsite (trihydrate).

Since this correspondence therefore in chemical composition to the three hydrates does exist, the question is naturally suggested, whether the mono- and tri- hydrates known as the minerals diaspore and gibbsite, do not really occur with physical properties different from those usually recorded. and closely resembling those of the mineral bauxite? In other words, is not what is called bauxite in some localities diaspore or gibbsite in a different physical state? Or, whether the commonly accepted formula for bauxite, $Al_2O_3.2H_2O$ or $Al(OH)_2$, must be modified according to locality to correspond to mono- di- or tri-hydrate as the case may be: and the general formula to be applied irrespective of locality and in its broadest usage, written $Al_2O_3.nH_2O$, in which *n* is variable and may correspond to one, two or three molecules of water.

Origin of the Bauxite Deposits.

The Georgia bauxite deposits have been studied in considerable detail by Spencer and Hayes and the theories advanced by them to explain the accumulation of the ore-bodies are discussed below at some length.

Dr. J. W. Spencer* suggested the following theory to explain the accumulation of the Georgia deposits:

"This is an open question. Its situation along with the iron and manganese ores in dolomites suggests a common genesis. The formation skirts the crystalline rocks of central Georgia, whence the materials were originally obtained. Prof. Branner says that the Arkansas bauxite, although in Tertiary rocks, is located near eruptive syenites, or hornblende granites. Such rocks in Georgia have given rise, in part, to the iron and manganese minerals. The feldspar, in others, contains the aluminium, and there remains only the necessary solvent to transport and deposit it as the mineral bauxite."

"In the weathering of the rocks carbonic and vegetable acids remove the iron, manganese, lime, etc., from the hornblende, and potash and soda from the feldspar. So also carbonic acid in water can dissolve small quantities of alumina; thus the same waters can remove the iron, manganese and alumina. The alkalies derived from the decay of feldspars can also dissolve the alumina. Thus transported, the alumina may be precipitated in the lagoons in which the ferruginous and manganiferous clayey limestones were being formed. The white clays associated with the bauxite and iron ore deposits are usually of fine texture, indicative of deposition in quiet waters. The frequent replacement of part of the alumina by ferric oxide further shows the presence of both metals in the original solution, but invariable quantities at different times and places."

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*The Paleozoic Group of Georgia, Geological Survey of Georgia, Atlanta, 1893, pp. 225-226.

"Upon the subsequent decomposition of the Knox limestone, the calcareous matter being removed, the ores were concentrated, leaving accumulations of bauxite more prominent than in the original beds."

"The position of the bauxite appears to be more or less in pockets and lenticular masses in certain strata, and if workings are ever carried beneath the decayed rocks, the mineral will likely be found in pockets in compact limestone. Indeed, some of the apparent clays may be found to be the soluble aluminous mineral, which is so far as known in Georgia, generally more or less oolitic and concretionary, as are the iron and manganese deposits. The bauxite beds or pockets are less interrupted, and are much more extensive than the latter named mineral."

Briefly summarized Dr. Spencer's explanation for the accumulation of the bauxite deposits is: (a) The source of the alumina was from the crystalline rocks of central Georgia; (b) the alumina was carried to its present place by carbonated or alkaline waters and precipitated in the lagoons in which the ferruginous and manganiferous limestones were being formed; and (c) the ore was further concentrated upon weathering of the Knox limestone, the soluble calcareous material of which was removed in solution, and the insoluble aluminous material, bauxite, was accumulated and left more prominent than in the original beds.

This theory fails to explain the following essential conditions and characteristic modes of occurrence of the Georgia deposits. (1) The deposits are compact ore-bodies existing in the form of well-defined pockets and, as a rule, with the vertical nearly equal to the horizontal dimensions. This mode of occurrence cannot by any known process apply to the accumulation of ore-bodies resulting from weathering. (2) The relationship of the bauxite and its associated kaolins to the surrounding residual siliceous material. In no instance has the gradation from the bauxitic clay into the inclosing residual clays been observed; but on the contrary, the line between the two is at all times definite and pronounced. The two types of clay bear no resemblance to each other. Furthermore the ore-bodies are free from included residual material. The concentration or accumulation of ore deposits from weathering *in situ* usually shows more or less residual material variously admixed, which forms the most convincing evidence in the case of deposits derived from rock weathering. This point is abundantly illustrated in the manganese and some of the iron deposits in the same region. (3) The relation of the deposits to the present topography of the region and their altitude above sea level. Upon Dr. Spencer's theory the ore-bodies if they represent accumulation from weathering of the Knox limestone should only occur at definite and uniform positions in that formation. On the contrary the deposits do not conform to these conditions, but are found in all parts of the Knox dolomyte, giving as Hayes[*] has shown, a stratigraphic range of at least 4,000 feet. (4) While the bauxite deposits in question are somewhat closely associated with those of iron and manganese, more particularly the iron, it by no means follows that the conditions suggest a "common genesis." In fact, recent work in this area conclusively demonstrates that the three types of ore-bodies are not of a common genesis. The manganese deposits of the Cartersville district represent undoubted residual accumulations concentrated by physical and chemical processes incidental to weathering. The ore deposits of iron and manganese are more intimately associated than any two metalliferous deposits known in the area and yet with several exceptions they have had a different origin.

The above facts constitute some of the essential features of the bauxite deposits which must be accounted for in any satisfactory explanation.

After a detailed study of the structural geology of the region and of the ore-bodies Dr. C. W. Hayes[†] suggests a theory for the origin of the Georgia deposits which is entirely different from the one formulated by Dr. Spencer. Hayes' theory is briefly stated by him as follows:[‡]

"The deposits are there [Georgia-Alabama region] found embedded in residual clay derived from the weathering of limestone. The limestone overlies a great mass of shales, and the formations are intersected by numerous faults, along which water has in the past found easy access to great depths. The shales are made up largely of silicate of aluminum. They also contain considerable iron sulphide in the form of pyrites. It is believed that the surface waters, carrying oxygen in solution, gained access to these shales and, by oxydizing the pyrites, set free sulphuric acid. This, under the conditions present, decomposed the aluminous shales, forming alum and sulphate of aluminum. Ascending currents carried these salts in solution to the surface, and, coming in contact with the limestone during their upward passage, they were decomposed, forming sulphate of lime and aluminum hydroxide, together with basic sulphate of aluminum, which was subsequently changed to aluminum hydroxide on exposure to the air. The aluminum hydroxide thus produced formed a gelatinous precipitate which collected about vents of springs. It was kept in motion by the ascending water and thus formed concentric structures. The reactions indicated above are all known to take place in nature, and the process is one which is readily understood."

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[*] Op. cited.

[†] Bauxite, *Sixteenth Annual Report. U. S. Geol. Survey*, 1895, part iii, pp. 587-591. This contains a very full and detailed statement of Dr. Hayes' theory.

[‡] Taken from the proof copy of Dr. Hayes' very valuable paper on "The Arkansas Bauxite Deposits," not yet issued from the press, but the anthor DR. HAYES very kindly placed at my disposal a proof copy of the report.

The essential facts which a satisfactory theory for the origin of the Georgia deposits of bauxite must explain are now stated in full. Some of these were stated in connection with Dr. Spencer's theory:

(1) The bauxite deposits in the Georgia district are mostly confined to the Knox dolomyte. They are not found at any uniform position in the dolomyte but are associated with all parts of the formation, giving a wide stratigraphic range.

(2) The ore occurs in the form of distinct pocket deposits of varying sizes and disconnected, with the vertical nearly equal to the horizontal dimension.

(3) The absence of foreign material, such as might be derived from the inclosing rocks in the ore-bodies and their associated bauxitic clays and kaolins. The pronounced difference in the bauxitic clays and the inclosing residual siliceous clays with no indication of commingling with or gradation into each other.

(4) The location of the deposits with reference to altitude and topography. Some of the ore-bodies occur below the 850-foot level, and a few are found above 950 feet; but where

erosion has not removed any considerable part of the deposits they are generally found near the 900-foot level.

(5) The prevailing pisolitic structure of the bauxite. The process producing the same structure in calcareous and siliceous materials has been observed and described. In such cases, where the process has been observed the pisolitic structure resulted from the deposition of the material in solution or from suspension in the form of a fine precipitate. Very likely, as Hayes says, this applies to all material having a pisolitic structure.

(6) The grouping or occurrence of the ore-bodies along apparent lines of weakness and about certain centres. Reference to the accompanying map makes this point clear.

(7) No eruptive rocks are yet known in the vicinity of the deposits, nor do any rocks occur in the region which by weathering could yield bauxite as a residual product.

The theory which best conforms to these premises is the one outlined by Dr. Hayes and briefly stated above, which as set forth by its author is based on the three essential features required of any satisfactory theory, namely: (1) the source from which the material was derived; (2) the means by which it was transported; and (3) the process of its local accumulation. Only the leading points under each one can here be stated.

(1) *The Source of the Alumina*: The Knox dolomyte, with which the deposits are associated, contains, as shown by numerous analyses, a very small percentage of alumina, which, by the process of accumulation required, is thought to be entirely inadequate as the source of the material.

Four analyses showed the composition of the Knox dolomyte to vary within the following limits:

SiO_2	3.75	to	7.252	per cent.
Al_2O_3 Fe_2O_3	1.236	to	1.76	" "
$CaCO_3$	34.07	to	53.44	" "
$MgCO_3$	36.32	to	55.736	" "

The following analyses of the Knox dolomyte and its accompanying residual clay from Morrisville, Calhoun county, Alabama, were made by Dr. W. F. Hillebrand* and described by professor I. C. Russell.† They are inserted here to illusrate the chemical changes incident upon the weathering of this rock. In his description of the magnesian limestone professor Russell makes the following statement: "The original rock in this instance was a grayish-white dolomyte typical of its class over a large area in the southern part of the Great Appalachian valley, while the clay left by its decay is a fair sample of the red soil of the South."*

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*Bulletin, U. S. Geol. Survey, No. 168, 1900, pp. 258 and 295.

†Ibid, No. 52, 1889, pp. 24-25.

Constituents.	Fresh Dolomyte	Residual Clay
SiO_2	3.24	55.42
Al_2O_3	0.17	22.17
Fe_2O_3	0.17	8.30
FeO	0.06	trace
MgO	20.84	1.45
CaO	29.58	0.15
Na_2O	——	0.17
K_2O	——	2.32
H_2O at 110° C	0.30	2.10
H_2O above 110° C		7.76
CO_2	——	——
Total	99.90	99.84

As indicated by the above analysis the residual product clearly represents a highly siliceous ferruginous clay, in which only a trace of the original more soluble calcium and magnesium salts is retained.

This Knox dolomyte, is underlaid, however, everywhere in the district by several thousand feet of calcareous clay or aluminous shales, which, as shown by the analyses below, contain 20 to 30 per cent. of alumina, in addition to the other constituents commonly found in the deposits, such as silica, titanic and iron oxides.

The following analyses indicate the general composition of the middle Cambrian shales of the bauxite region:

	I.	II.
SiO_2	55.02	52.82
Al_2O_3	21.02	26.17
Fe_2O_3	5.00	9.46
FeO	1.54	....
MgO	2.32	1.08
CaO	1.60	trace

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*Ibid, p. 24.

I. Middle Cambrian shale. Coosa valley, near Blaine, Cherokee County Alabama. Dr. H. N. Stokes, analyst. *Bulletin No. 168 U. S. Geol. Survey* 1900, p. 283.

II. Oostanaula shales about two miles northwest of Cartersville, Bartow County, Georgia. J. W. Spencer, Paleozoic Group, Geol. Survey of Georgia, 1893, p. 285.

Na_2O	0.81	0.20
K_2O	3.19	2.71
H_2O at 110° C	2.44	0.23 (hygroscopic.)
H_2O above 110° C	5.65	7.00 (combined).
TiO_2	0.65	....
P_2O_5	0.06	....
MnO	trace	....
BaO	0 04	....
SrO	trace	....
Li_2O	0.03	....
SO_3	0.02	....
Cl	trace	....
CO_2	0.83	....
Carbonaceous matter	0 32	....
Total	100.54	99.67

The Connasauga shales (Cambrian) are believed therefore to have been the source of the material.

(2) *The Means of Transportation*: The formations of the district, both limestone and shale, are intersected by numerous faults, which afforded in the past easy access for the percolation of waters. The descending waters carrying oxygen in solution reacted chemically on the aluminous shales, which contained disseminated pyrites, taking into solution the sulphates of aluminum and iron, which salts were returned to the surface by the ascending waters. The upward passage of these salts in contact with several thousand feet of limestone resulted in a further chemical reaction, forming probably, as in the chemical laboratory, aluminum hydroxide and basic sulphate of aluminum.

(3) *The Process of Accumulation*: The ascending currents bearing the aluminous salts in solution are believed to have reached the surface near or upon the fault lines forming large springs, which were probably thermal, and the aluminum hydroxide produced as described by Hayes formed a gelatinous precipitate, which collected about the vents of the springs. From analogy with pisolitic sinter and travertine now forming such conditions would appear to be highly favorable for the production of the structure actually found in the bauxite. The precipitate was apparently collected in globular masses by the motion of the ascending water, and constant changes in position permitted these to be coated with successive layers of more compact material. Finally after having received many such

coatings, the pisoliths were deposited on the borders of the basin, and the interstices were filled by minute oöliths formed in a similar manner or by the flocculent precipitate itself. Slight differences in the conditions prevailing in the several springs, such as concentration and relative proportion of the various salts in solution, also temperature and flow of the water, would produce the variation in the character of the ore observed at different points."

The theory above outlined was originated and applied by Dr. Hayes to the Georgia-Alabama deposits. It is here reviewed and discussed at some length for the reason that after a careful study of the same region by the writer, Dr. Hayes' theory more completely covers the essential features required of a satisfactory theory and explains the conditions in the field as the writer saw them, than any one yet advanced.

Age of the Deposits.

Dr. Hayes* has given an excellent presentation of the physiographic development of northwest Georgia, and the contiguous parts of Alabama and Tennessee. Hayes points out in this development three levels of planation in the bauxite area, the two oldest ones corresponding in age to the Cretaceous and Eocene periods, respectively. It is further shown that the surfaces of the dolomyte plateau and ridges of the bauxite region determine the Eocene base-level plain, corresponding to an altitude of about 950 feet above sea level. The majority of the bauxite-deposits where not deeply eroded are found between the levels of 900 and 950 feet. Since the altitude of the deposits corresponds closely to that of the Eocene peneplain, they could not have been formed previous to that time as the ore-bodies are shallow surface deposits. Nor could they have been formed after the plain was uplifted and eroded without changing the place of deposition of the ore-bodies. This would apparently fix the age of the bauxite deposits sometime near the close of the Eocene.

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*Op. cited, pp. 551-562.

Physiography of the Chattanooga District, in Tennessee, Georgia, and Alabama. *Nineteenth Annual Report, U. S. Geol. Survey*, 1897-98 (1899), part ii, pp. 1-58.

THE AGE OF THE KANSAS-OKLAHOMA RED-BEDS.

By J. W. Beede, Effingham, Kansas.

The "Red-beds" of Kansas and Oklahoma have been referred to all the geologic periods from the Permian to the Cretaceous inclusive. Until recently no fossils have been known from these deposits. The thickness of these beds in Kansas is about 1,150 feet.

A few years ago Prof. C. N. Gould found some imperfectly preserved ostracod crustaceans which Mr. T. Rupert Jones referred to a Triassic group of the genus *Estheria* under the name *Estheria minuta*. A little later Prof. Gould found some excellent specimens of *Eriops*, a Permian vertebrate, associated with these same fossils, all of which came from near the base of the beds, leaving the age of a majority of them still in doubt, especially those above the great gypsum beds.

Last summer professor Gould, with a party of the Oklahoma geological survey, discovered fossil invertebrates at Horse Springs, west of Alva, O. T., above the Cave Creek gypsum nearly at the top of the red-beds. The fossils were submitted to the writer for identification and later to Mr. Charles Schuchert, who offered some valuable suggestions. They are mainly pelecypods with a species of brachiopod and a few gastropods.

Though no species of *Conocardium*, so far as I am aware, is known from the Lower Permian of Kansas or Oklahoma, yet this Carboniferous genus is represented in the collection. *Aviculopecten occidentalis* (Shum.) Meek, is also present and one other species bearing somewhat of a resemblance to it but quite different from it in some respects, is also present. One of the common fossils is a biplicate terebratuloid, *Dielasma schucherti* Beede,[*] belonging to a group of this genus heretofore unknown in the American Permian. Mr. Schuchert informs me that it is very similar to a species of this genus described by Waagen from the Permian of Europe.

Among the other genera represented are *Schizodus*, *Naticopsis* and *Pleurophorus*.

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[*] See forthcoming *Rep. Geol. Surv. O. T.*

The presence of these fossils clearly demonstrates the Permian age of these rocks, coming as they do from very near to the top of the beds.

Taking this into consideration the thickness of the Permian in southern Kansas is about [illegible] feet, allowing [illegible] feet for the Upper Permian (Red-beds) and [illegible] feet for the Lower Permian (Wellington, Marion, Chase and [illegible]).

A SHORT DISCUSSION OF THE ORIGIN OF THE COAL MEASURES FIRE CLAYS.

By T. C. Hopkins, Syracuse, N. Y.

Fire clay is one of the terms in common usage that has been adopted into geological literature and it is not possible to give a scientific definition that would cover its usage by all classes. The manufacturers use the term for a highly refractory clay, although they probably would not all agree as to the degree of refractoriness that a clay must have to be properly termed a fire clay. Professor Wheeler draws the line at [illegible], that is, a clay that withstands a temperature of [illegible] without fusion may be properly designated a fire clay.* The coal miner and the clay miner in the coal regions use the term for all the clays that underlie the coal seams, [illegible] all the [illegible] seams [illegible] silicate [illegible] of the [illegible] earths [illegible]

[illegible] many [illegible] fire clays [illegible] by the miner [illegible] high grade refractory [illegible] cur in the [illegible] term, as applied [illegible] venient [illegible] ination the [illegible] and those [illegible] ports the term [illegible] chemical and the fire resisting qualities have later been determined in the laboratory they can then be distinguished as pure and impure, high grade and low grade, or poorly refractory and highly refractory.

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* Missouri Ge[illegible]

While the present paper deals principally with the blue clays of the Coal Measures, the term fire clay, of course, cannot properly be limited to these clays, as valuable refractory clays occur in strata both older and newer than the Coal Measures without any connection with coal seams of any kind. Thus, in Missouri, fire clays occur in Lower Carboniferous, Silurian, and Ordovician strata and in New Jersey in Cretaceous or more recent. Many of the residual kaolins of the Piedmont belt are highly refractory.

The explanation commonly offered for the origin of the blue fire clays of the Coal Measures is that they are the soils on which grew the vegetation that forms the coal seams lying on top of them, and the reducing and leaching action of the vegetable acids from the living and the decaying vegetation has changed the common clay to the refractory fire clay. This appears to be a satisfactory explanation for many of the clays, but there are some of the deposits that are not satisfactorily explained in this way.

The deoxidizing and leaching action of both living and decaying vegetation is illustrated in many of the bogs and swamps of the present, and in a less degree in the meadow and the forest soil. The organic acids of the vegetable matter are strong reducing agents and under their action the red and yellow ferric oxides are changed to the lower gray or bluish ferrous oxide in which form it is soluble in the acids, and where there is sufficient circulation the iron may be either carried away in solution or segregated into beds of iron ore. Fragments of minerals containing alkalies and alkaline earths may be broken up by the vegetable acids into separate compounds and the alkaline substances dissolved in the water and part carried away in solution and part may be taken up by the plants and held in the carbonaceous matter of the muck of the bog of the present or the coal bed of the older period. It sometimes happens that there is better drainage into the bog than out of it, and the iron leached from the surrounding region may be carried into the bog and deposited as an iron ore.

The general order of occurrence is first the clay overlain by the ore, followed by the coal, but it frequently happens that one or more of these substances are lacking. Sometimes it is the ore, sometimes both the ore and the coal, and less commonly the clay. That is, in some places coal seams occur without any underlying clay, and in many places the clay occurs without any overlying coal. Again, it frequently happens that the clay may form one or more seams in the coal bed; thus, in the famous Pittsburg coal seam in southwestern Pennsylvania, and in West Virginia, the inclosed fire clay seams, several in number, are remarkably persistent and regular in thickness over wide areas.

We find some phenomena in connection with the occurrence of the fire clays, and the coal seams that are difficult to harmonize with the above outlined theory of origin. Thus, if the fire clay is the soil on which grew the vegetation that forms the coal, and in so doing changed the common clay to fire clay, how are we to explain (1) the occurrence of fire clay beds free from coal of any kind, (2) that such clay is frequently of better quality, that is, more refractory than that which is overlain by coal, (3) the great thickness of some of the beds, and (4) the coal seams deposited on yellow shales or sandstones entirely independent of any fire clay?

(1) *Fire clay beds not overlain by coal.*—Comparatively little is given on this point in the literature, but the observations of the writer in several different coal basins lead him to think that this is a rather common occurrence. In Clearfield, Indiana, Westmoreland, Clinton, and Tioga counties, Pennsylvania, these coalless fire clay seams occur in considerable numbers.

The fire clay in these cases might have been formed in the usual way, and the absence of the coal explained by the fact that (*a*) the carbon might have been oxidized, owing to long exposure before the overlying sediments were deposited, or (*b*) the carbonaceous material may have been eroded before the deposition of the next stratum. (*c*) Another and, in some instances more probable explanation, is that the clay was fire clay before it was deposited in its present position, that is, it was changed to fire clay in some other locality and was then eroded and transported as sediment and deposited in its present position in much the same condition as it is at present.

(2) *The clays that occur free from the coal seams are apt to be more refractory than those underlying coal seams.*—It is a matter of observation that the most refractory clays in the Coal Measures are found among those which have no coal overlying them. This may be due partly to greater original purity and partly to a leaching subsequent to the elevation of the land. Thus the secondary deposition of the clay would tend to remove a greater percentage of the soluble bases that form the fluxing constituents and after the elevation of the land the leaching by the meteoric waters would tend to still further remove the soluble materials. The texture of clay is not favorable to the rapid percolation of water, but the slow circulation through a long period of time may accomplish the same result. The accumulation of the iron carbonate ("the ore balls") so abundant in some places, shows that the water does percolate through the clay to some extent. Where the clay is overlain by coal, the tendency is often the opposite to the above and iron is carried into the clay from the oxidizing pyrite in the overlying coal.

(3) *The great thickness of some of the clay beds.*—In some places the fire clay deposits are thirty feet or more in thickness. One can hardly conceive how the vegetation growing on the top of a deposit of this thickness would extract the iron and the alkalies from the entire body of the clay. If it were formed in this way one would naturally expect the upper part to be the purest, and at least some considerable portions of the middle and lower portions to be unchanged. Instead we find, so far as there is any difference, that the lower part is likely to be the best clay and the poorest part at the top.

At Bolivar, Pa., the flint fire clay is over twenty-five feet thick and overlying it between the clay and the coal there are several feet of shale. How would it be possible for the plants of this coal seam to leach out the iron and alkalies from twenty-five feet of clay when there are several feet of unchanged shale lying between them?

At Blossburg, Pa., there is a bed of fire clay 15 to 25 feet thick, with no coal or carbonaceous matter associated with it, and no fossil plant remains in so far as known. The laminated structure of this deposit is additional evidence in support of the belief that the clay was fire clay at the time of its deposition and not clay that has been changed in situ.

[illegible] underlain [illegible] not [illegible] instan[illegible] underlain [illegible] son[illegible] instan[illegible] derivin[illegible] den[illegible] the [illegible]

In [illegible] the [illegible] is [illegible] reduc[illegible] mor[illegible] by [illegible] then [illegible] the [illegible] probab[illegible] of [illegible] tion [illegible] positio[illegible]

NOMENCLATURE OF THE CAMBRIAN FORMATIONS OF THE ST. FRANCOIS MOUNTAINS

[illegible]

[illegible] Ozar[illegible] tains [illegible] thic[illegible] geologic[illegible] tended dis[illegible] port[illegible] tion, nor the sa[illegible] of the reg[illegible] quence. A[illegible] the reasons [illegible] special report [illegible]

Missouri Geolog[illegible]

By paralleling the general sections, the exact stratigraphical relationships of the various formations may be clearly represented.

WINSLOW, 1896.	KEYES, 1895.
	?
Potosi limestone	?
	Le Sueur dolomyte
St. Joseph limestone	Fredericktown dolomyte.
La Motte sandstone	La Motte sandstone
Iron Mountain conglomerate	

The names defined by Winslow were incidentally mentioned by him a year previous* to the publication of his descriptions, but at that time without definition. When they were formally proposed† another set of names had been defined for the same region.

Stratigraphically, the Iron Mountain conglomerate cannot be considered as a distinct geological terrane, unless the original signification of the title be wholly changed and restricted to the conglomerates encircling the peak of Iron mountain alone. On the same horizon of unconformity and over a large area, similar conglomerates occur. These beds are not only not continuous, but they are often widely isolated and usually of very local extent. Moreover, if it were desirable to have a name undefined stand for this conglomerate the term suggested would have priority in another sense. It was used with definite application to the porphyry of the region.‡ The recognition of the porphyry as a distinct formation is all the more significant since it has been found that it is really the upper part of the general granite mass of the area.§ The conglomerates when they occur may be properly regarded as local basal facies of the La Motte sandstone.

In both of these sections mentioned above, the stratigraphical delimitation of the La Motte sandstones is essentially the same. The same is true, to all practical intents, of the Fredericktown formation. Regarding the title St. Joseph that is used in the bulletin of the Federal survey, it may be said that the definition of the formation was not published until a year after that of the Fredericktown.* To be sure, the title St. Joseph appears in the lead and zinc report of Missouri, published in 1895, but it was merely a name in a table of provisional formations, and was given as an alternate with St. Francois limestone. In spite of this fact, this name might have been adapted at the time in the special report on the Mine la Motte district and used in place of Fredericktown had it not been for the circumstance that essentially the same name had been previously proposed† in due form for an important terrane in northern Arkansas—the St. Joe marble formation.

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* *Missouri Geol. Sur.*, vol vi, 1895, p. 331.
† *Bull. U. S. Geol. Sur.*, No. 132, 1896, p. 11.
‡ *Missouri Geol. Sur.*, vol. vi, 1894 p. 30.
§ *Bull Geol. Soc. America*, vol. vii, 1896, p. 363.
U. S. Geol Sur., Bull. 132, 1896, p 11.

The LeSueur dolomyte‡ of the Mine la Motte district, represents only about the lower third of what was later denominated the Potosi limestone. The latter name, moreover, like St. Joseph, was merely mentioned in the general lead and zinc report. As a matter of fact, little is really known about the stratigraphy of what is colored as the Potosi limestone on the map accompanying the bulletin of the United States Geological survey. And it is exceedingly doubtful whether the beds which have been termed the LeSueur in the Mine la Motte district are represented at all in the Potosi limestone further north near the typical locality.

EDITORIAL COMMENT.

THE SUPPOSED RECENT SUBMERGENCE OF SIBERIA.

Prof. G. F. Wright finds that the country skirting the great central Asiatic table-land is loaded with the fine deposit known as "Loess." This consists of water-borne deposit for the most part though in the east the aeolian origin as maintained by professor Richthofen, seems very probable. If this material is of glacial origin ultimately, as is the case in other parts of the world, this view merely explains its mode of deposition. It must, then, be the "glacier-milk" of the glacier-system of the central plateau brought down by the rivers that flow down the long slopes and dropped on the lowlands adjoining.

But professor Wright says that the altitudes of the strata of loess are such as to prove a subsidence of the whole region in-

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**Missouri Geol. Sur*, vol. ix, 1895, pt. iv, p. 48.
†*Arkansas Geol. Sur.*, Ann. Rep. 1890, vol. iv, 1893, p. 253.
‡*Missouri Geol. Sur.*, vol. ix, pt. iv, 1895, p. 52.

[illegible]

[illegible]

[illegible] This far [illegible] might well be filled with [illegible]

[illegible] excellent opportunities for [illegible] illustrative material for other branches of the science are far from abundant. The scarcity of material at hand has been a factor in the development of the methods used by professor Calvin.

Textbooks and other literature are recommended, and the students' reading is directed, but no definite assignments are made, nor is any attempt made to follow the text in the presentation of the subject. The department is stored with a great variety of specimens illustrative of dynamical, physiographic, and historical geology. These materials are in daily use, and it is one of professor Calvin's maxims, that a lecture in geology without specimens to illustrate it, is an imposition. The lecture-room is furnished with table-like desks accommodating eight students each, and affording room for the free use of specimens during the lectures. Rapid chalk-sketching and tabulation are used whenever the subject under discussion makes it possible.

Perhaps the most unique feature of the methods, is the constant use of camera and lantern. The camera had been made to bring the outside world into the classroom, and large collections of lantern slides and sets of photographs are used to illustrate the grander structural and physiographic phenomena. In addition to this use of photography, each student, during the course gets between sixty and seventy large kallitype plates to illustrate his permanent notebook. These plates include over five hundred figures of physiographic features, structural forms and fossils. The students furnish the paper, and it is sensitized and printed in the department laboratory. Students who can do so, may use the negatives and make their own plates.

The outlines of lectures taken in the classroom are elaborated and the work is re-written on flat paper and bound with the plates in patent covers. These permanent notebooks are called in, corrected and graded twice a term. With classes that meet five times a week, written or oral reviews are given about once a week.

Regular field trips are made as frequently as possible. Before the close of the year, each student collects material from all sources in the neighborhood of the city and presents it in the classroom with a written sketch of the geology of the region.

D. R. G.

RIVER PROFILES.

An interesting and valuable publication of the Department of Hydrography of the United States Geological Survey on the Profiles of Rivers in the United States by Henry Gannett, has just been published and is now available for distribution. It embodies within 100 pages the leading facts of about 150 of the most important rivers and streams of the country, noting their length, drainage area, the location of water power in their courses, their peculiarities of flow and the nature of their drainage basins.

The rivers selected are those which are the largest in size and bear most directly upon the varied interests of the country such as the Connecticut, Hudson, Susquehanna, Ohio, Potomac, Mississippi, Missouri, Platte, Colorado, Sacramento, Columbia, and others. The figures for the tables showing hight above sea level and fall per mile were collected from various sources. Some were obtained from the report of the Chief Engineer of the United States Army, some from railroad companies when their lines cross the streams and some from the atlas sheets of the United States Geological Survey.

In the case of such rivers as the Connecticut, Susquehanna, Mississippi and Colorado, where the surrounding country is, in part or whole, of peculiar physiographic interest, very excellent and vivid descriptions of its leading physical characteristics are given which add to the interest and render it valuable from an educational standpoint in geographic and physiographic instruction.

The pamphlet is the result of much careful work and is the first attempt to collect and compile this information in its present form.

GUIDE TO THE GEOLOGY OF NIAGARA FALLS.

We referred in the last number of the GEOLOGIST to Mr. G. K. Gilbert's résumé of the Falls of Niagara, and to the map of the region lately issued by the United States Geological Survey. More recently a more complete "guide to the geology and paleontology of Niagara Falls and vicinity" has been published by the New York State Museum, as Bulletin No. 54, vol. ix, April, 1901. It is by Dr. A. W. Grabau, of the Rensselaer Polytechnic Institute, at Troy, N. Y. It also contains a glossary of paleontological nouns and adjectives not generic nor specific, these being gathered in an index. The preface is by Dr. John M. Clarke. This work is accompanied by a geological map of the Niagara river by Dr. Grabau, and by several plates showing natural scenery. Dr. Clarke states that it is a volume produced by the co-operation of the Buffalo Society of Sciences and the department of paleontology of the New York State Museum, but the work of collection of the data and the discussion of the same is wholly by Dr. Grabau. It is very thoroughly and carefully done, and the volume certainly constitutes a suitable and creditable summary of the work of the century bestowed by geologists on the features of the cataract and its gorge, and on their pleistocene history. The geologists of the coming century, having this epitome and guide, will certainly have no mean opinion of the labor of their predecessors on this greatest object lesson of pleistocene geology.

The investigations of Hall, whether on the measurements of the gorge or on the rocks and their fossils, in 1837-43, of Lyell, Logan, Gilbert, Upham, Spencer, Leverett, Taylor and others, and their aggregate results, are here cast into one mold, from which is obtained a consistent general history of the gorge and of the falls. The volume, however, is more than this. It discusses the entire geologic history of the region, detailing the physical changes which were introduced by the successive epochs. It also enumerates, with brief descriptions and numerous illustrations, the fossils that have been found in the region pertaining to the Silurian. The fossils of the Devonian are not enumerated. The last chapter is a distinct contribution to science, being a complete catalogue, with descriptions and references to authorities of the post-Pliocene fossils of the Niagara gravels, by Elizabeth J. Letson, director of the museum of the Buffalo Society of Natural Sciences. These post-Pliocene fossils are from Goat island, Prospect park, Queen Victoria park, Muddy creek, Whirlpool (both sides of the river) and Foster's flats. These fossils are also described and illustrated. The appendix consists of a "partial bibliography of the geology of Niagara and the great lakes."

The volume is destined to become a classic of geological literature, equally suitable for the drawing room and the classroom.

N. H. W.

REVIEW OF RECENT GEOLOGICAL LITERATURE.

Nitrates in Cave Earth. By Henry W. Nichols. (*Jour. Geol.*, Vol. IX, pp. 236-243.)

This is in the main a criticism of the theory advanced by Hess (*Jour. Geol.*, Vol. VII, p. 2) that the nitrates of cave earth are not derived to any great extent from bat guano, as has been formerly supposed, but from the soil above by a leaching process followed by a deposition of the salts on evaporation. The chief objections raised by Mr. Hess to the old theory may be briefly summarized as follows:—1. Bats do not penetrate far into caves, which makes it difficult to account for the presence of salts derived from guano and their uniform distribution in the caves. 2. Cave earths contain little or no organic matter. 3. While the total phosphates in the guano and underlying earth are about equal, the soluble phosphates are much less in the earth. In criticising these objections it is shown, that bats do penetrate into remote parts of the caves, that in some instances cave earths do contain organic matter and that the lack of soluble phosphates in the earth is due to a simple reversion of the soluble to an insoluble form. Among other things to which attention is called is the presence of carbonates in the drip waters of the cave and their absence in the cave earths, a fact which Mr. Hess's theory does not account for. It is thought that the amounts of phosphates and nitrates taken into solution from the soil are too small to account for the amounts found in the earth and that the considerable quantities of soluble salts in the bat guano furnish a more probable source of supply. The author therefore concludes that the old theory agrees with the facts better than the new. C. H. W.

Mohawkite. By Joseph W. Richards. (*Am. Jour. Sci.*, *161*. 457-458.)

Under the name mohawkite a mineral was described by Ledoux (*Eng. & Min. Jour.*, Apr. 7. 1900,) to which he assigned the formula $(Cu\,Ni\,Co)_4As$. Later the correctness of his work was called into question by Koenig, who appropriated the name mohawkite for a mineral which he described (*Am. Jour. Sci.*, Dec., 1900,) as having the composition $(Cu\,Ni\,Co)_3As$. A new analysis is reported in the present paper, confirming the correctness of Ledoux's work and proving the existence of a molecule $(Cu\,Ni\,Co)_4As$. The name ledouxite is proposed as a name for the latter. C. H. W.

(*On the origin of the Phenocrysts in the Porphyritic Granites of Georgia* By Thomas L. Watson. (*Jour. Geol.*, Vol. IX, pp. 97-122.)

A detailed petrographical description is given of the porphyritic granites of Georgia, within the Piedmont plateau. The different areas are taken up according to their geographical distribution. The following facts given by the author concerning these rocks are believed to indicate that the phenocrysts (orthoclase) have been formed in place and are not of intratelluric origin:—1. The absence of a definite arrangement or orientation among the phenocrysts. 2. Absence of phenocrysts from the border zones of the granite masses and a gradation peripherally from an interior porphyritic facies into an even-granular granite of coarse texture and of the same mineral and chemical composition. 3. The absence of any evidence of magmatic resorption or corrosion of the phenocrysts. 4. The absence of any flow structure. 5. The abundant inclusions of all the ground mass constituents, a feature very characteristic of these porphyritic granites. A table of the chemical analyses of these rocks accompanies the article.

C. H. W.

Studies for Students. By O. C. FARRINGTON. (*Jour. Geol.*, Vol. IX, pp. 51-65 and 174-190.)

This is a study of meteorites in regard to their chemical and mineralogical composition, their petrographical characteristics, their terrestrial analogies, and to some of the theories relating to their origin.

C. H. W.

Mineralogical Notes. By C. H. WARREN. (*Am. Jour. Sci.*, *161*, 369-373.)

The following minerals are described:—anorthite crystals occuring as a contact mineral in the limestone at Franklin Furnace, N. J.; soda orthoclase crystals of peculiar habit from a phonolyte dike, Cripple Creek, Colo.; iron wolframite crystals from South Dakota; pseudomorphs of wolframite and scheelite from Trumbull, Conn. C. H. W.

A Text-Book of Geology. By A. P. BRIGHAM. D. Appleton & Co. 1901.

This volume is intended for use in secondary schools. It is the latest of the series of *Twentieth Century Text-Books,* and like its predecessors, it is admirably bound and illustrated. Its treatment of the subject is physiographic in standpoint, its style simple, and its language untechnical. Dynamical and structural geology are treated in a manner well suited to explain the essential facts to young students, while at the same time its conceptions are thoroughly up to date. Its treatment of historical geology is over-brief, being merely a summary of life development and of continental evolution. There are excellent pictures of fossils, but the discussion of them brings out little beyond geographic distribution. No attempt is made either at a phylogenetic interpretation of fossils, nor is the method of determining geological horizons by means of them discussed. There is no suggestion of the manner of interpreting past conditions from the paleontological evidence. The term Lower Silurian is retained in preference to the more generally accepted Ordovician.

The book is the best elementary text-book yet produced. As Gilbert said in his Lake Bonneville Monograph, "it is through the study of the phenomena of the latest period that the connection between present processes of change and the products of past changes is established." Mr. Brigham is the first to make in a text-book the true use of physiography, not as a separate department of geology, but as the key to all the others. With biological and stratigraphical explanations from the teacher, the book will be admirably suited to the purpose for which it is intended. I. H. O.

MONTHLY AUTHOR'S CATALOGUE
OF AMERICAN GEOLOGICAL LITERATURE ARRANGED ALPHABETICALLY.

Bagg, R. M. Jr.

Protozoa. (Md. Geol. Sur., Eocene. pp. 233-257. pls. 62-64. 1901.)

Blake, W. P.

The Caliche of southern Arizona, an example of deposition by the vadose circulation. (Trans. Am. Inst. Min. Eng.. Richmond meeting. 7 pp. Feb., 1901.)

Branner, John C.

Annual report of the Geological Survey of Arkansas for 1892 Vol v., with an atlas. The Zinc Lead Region of north Arkansas. pp. 395. 38 pls. Little Rock, 1901.

Case, E. C.

Reptilia. (Md. Geol. Surv., Eocene. pp. 95-97. pls. 10, 11. 1901.)

Clark, W. B. (and G. C. Martin)

Echinodermata. (Md. Geol. Surv., Eocene. p. 232. pl. 61. 1901.)

Clark, W. B. (and G. C. Martin)

Brachiopoda. (Md. Geol. Surv., Eocene. pp. 203-204. pls. 58. 1901.)

Clark, W. B. (and G. C. Martin)

The Eocene deposits of Maryland. (Maryland Geological Survey. Eocene. pp. 19-92, pls. 1-9. 1901.)

Clark, W. B. (and G. C. Martin)

Mollusca. (Md. Geol. Sur., Eocene, pp. 122-202. pl. 17-57. 1901.)

Cragin, F. W.

A study of some Teleosts from the Russel substage of the Platte Cretaceous series. (Col. College Studies. vol. 9. pp. 25-37, 2 plates. May, 1901.)

Daly, R. A.

Marine currents and river deflection. (Science. vol. 13. June 14. 1901. p. 902.)

Eastman, C. R.

Pisces. (Md. Geol. Surv., Eocene. pp. 98-115, pls 12-15. 1901.)

Eckel, E. C.

The Portland cement industry in New York. (Engineering News, May 16, 1901.)

Fisher, O.

Rival theories of Cosmogony. (Am. Jour. Sci., vol. 11. June, 1901. pp. 414-423.)

Gannett, Henry.

Profiles of rivers in the United States. Water Supply and Irrigation papers, No. 44. U. S. Geol. Surv., pp. 100, 11 plates, map. 1901.)

Grabau, A. W.

Guide to the Geology and Paleontology of Niagara Falls and vicinity. Bull. N. Y. State Mus., No. 45, vol. 9, April, 1901.)

Greene, G. K.

Contribution to Indiana Paleontology. Part VII, pls. 20, 21, pp. 50-61. May 23, 1901. New Albany, Ind.)

Hague, Arnold.

Report on the congress of geologists. (Ex. from the report of the Commissioner-general for the United States to the International Universal Exposition, Paris, 1900. Vol. 6, pp. 197-204.)

Hollick, Arthur.

Plantæ. (Md. Geol. Sur., Eocene, pp. 258-260, pl. 64, 1901.)

Keyes, C. R.

Horizons of Arkansas-Indian Territory coals compared with those of other trans-Mississippian coals. (Eng. & Mining Jour., vol. 71, p. 692. June, 1, 1901.)

Knight, W. C. (and E. E. Slosson)

The Dutton, Rattlesnake, Arago, Oil Mountain and Powder River oil fields. (Bull., School of Mines, Wyo., pp. 57, maps. April, 1901.)

Lambe, L. M.

Notes on a turtle from the Cretaceous rocks of Alberta. (Ott. Nat., vol. 15, p. 63. June, 1901.)

Lambe, L. M.

A revision of the Genera and species of Canadian Paleozoic corals. The Madreporaria aporosa and rugosa. (Cont. Can. Paleontology. Vol. 14. Part 2, pp. 97-198, pls. 6-18. Ottawa, 1901.)

Lane, A. C.

Michgan limestones and their uses. (Eng. and Min. Jour. vol. 71, pp. 662 and 693. May 25 and June 1, 1901.)

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Martin, G. C. (W. B. Clark and)

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Martin, G. C. (W. B. Clark and)

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Morganroth, L. C.

The caves of Huntingdon county, Pa. (Eng. and Min. Jour. vol. 71, p. 664. May 25, 1901.)

Newland, D. H.

The serpentine of Manhattan island and vicinity and their accompanying minerals. (Schl. Mines Quart., vol. 22, pp. 307-318. April, 1901.)

Nutting, C. C.

The sea bottom—Its physical conditions and its fauna. (Science, vol. XIII, p. 841. May 31, 1901.)

Pearson, H. W.

Oscillations in the sea-level. III. (Geol. Mag. vol. 8, pp. 253-265. June, 1901.)

Richards, J. W.

Mohawkite. (Am. Jour. Sci., vol. 11, p. 457. June, 1901.)

Ries, Heinrich,

Clays and Clay products at the Paris Exposition. 1900. (U. S. Geol. Sur.,. (21st Annual Report. Part VI (continued) pp. 365-392. 1901.)

Ruedemann, Rudolph

Hudson River beds near Albany and their Taxonomic equivalents. (Bull. N. Y. State Mus., No. 42, vol. 8, pp. 489-587. pls. 1, 2. April, 1901.)

Shattuck, G. B.

The Pleistocene problem of the North Atlantic coastal plain. (Johns Hopkins University circulars, No. 152. May, 1901.)

Ulrich, E. O.

Bryozoa. (Md. Geol. Sur., Eocene, pp. 205-221. pls. 59. 60. 1901.)

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Van Ingen, G.

The Siluric fauna near Batesville, Arkansas. (Schl. Mines Quart., vol. 22, pp. 318-329. April, 1901.)

Vaughan, T. Wayland

Coelenterata. (Md. Geol. Sur., Eocene, pp. 222-231, pl. 16. 1901.)

Wieland, G. R.

Study of some American fossil Cycads, part IV. Microsporangiate Fructification. (Am. Jour. Sci., vol. 11, pp. 423-436. June, 1901.)

Wortman, J. L.

Studies of the Eocene mammalia in the Marsh collection. Peabody Museum, plate 6, pp. 437-450. June, 1901.

PERSONAL AND SCIENTIFIC NEWS.

PROF. H. C. BEELER, of Cambria, Wyo., has been appointed state geologist of Wyoming.

THE NEXT MEETING OF THE INTERNATIONAL MINING CONGRESS will be held at Boise, Idaho.

MR. W. S. GRESLEY, late of Erie, Pa., has returned to England. His address is Derby, Eng.

PROF. J. C. HARTZELL, of the Illinois Wesleyan University, is engaged for the summer with the Indiana Geological Survey.

PROF. C. E. VAN BARNEVELD, of Minneapolis, has recently made a professional trip to Grand Encampment, Wyo., and to Tintic, Utah.

at $221,970. None of these lands have been sold. The buildings erected at Butte were not paid for by the state, but by thirty-year bonds secured by these lands, the state, however, having guaranteed both principal and interest.

MR. H. W. PEARSON, OF DULUTH, recently brought a novel suit against the Great Northern Railroad company. It was tried at St. Paul and the question at issue, viz: that of a money consideration of a million and a half of dollars for discovering coal in Montana and Washington, was left undecided by a disagreement of the jury.

Mr. Pearson induced the president of the Great Northern company (Mr. J. J. Hill) to employ him to search for coal along the line of the Great Northern R. R. in 1896, under the guidance of a new hypothesis and law which he (Pearson) claimed to have discovered. The law of Pearson, on examination by competent geologists, proved to be wholly groundless and puerile. It assumed that the earth's crust has never been elevated and depressed, that the ocean had flooded alternately the northern and the southern hemispheres under the disturbing action of ice-caps as suggested by Croll, that such flooding disrupted the then growing forests and carried the *debris* as driftwood against pre-existing highland barriers that were not submerged, that such driftwood, so lodged, was accumulated so as to form coal, that all coal "on earth" could thus be located when once the topography and the oceanic currents were known, that the deposits of Wales, those of Pennsylvania, Ohio etc., were of glacial or post-glacial date, that the Montana and Washington coals, whether Cretaceous or Tertiary, were of the same age as those of Wales and Pennsylvania, that the coals known to have greater elevation were of earlier date than those of lower altitude, that the Crollian submergences were greater in earlier geological (glacial?) time than in the later, that the evidences of such submergences consist in the beaches that are scattered over the country, that the beaches that have been described about glacial lakes in the United States such as the "boulevard beach" at Duluth, and those of lake Agassiz, aré ancient ocean beaches, and cotemporary, that the Columbia formation of the Atlantic sea-board, and the Lafayette of the interior, were cotemporary, and due to the same submergence, that the whole science of geology was to be remodeled on this law, forming a "new geology," and that this new geology was simply a reversion to the geological principles that were in vogue a hundred years ago.

Strange to say, this wild, anarchistic notion figured largely in the suit. Be it said, however, to the credit of the intelligence of the jury, the disagreement was due not to the theory but to a difference of opinion as to actual, original discovery of any coal by Pearson, for he had designated certain coal beds as probably valuable, and the Great Northern Railroad company had entered upon them.

It was shown that the coal designated by Pearson lay in the coal basin that had been described in the tenth United States census report (1880), by W. M. Davis and G. H. Eldridge, and Dr. J. S. Newberry, and by Messrs. Weed and Pirsson, several years before Pearson saw it. It was also shown that a part of the area under contest (the Cottonwood coal area at Stockett) had been examined by the agents of the Montana Central R. R. company and had been by them passed to the Great Northern R. R. company, that other parts had been examined by drilling and had been mapped by the agents of the Sand Coulee Coal company, and that the Great Northern R. R. company had itself decided to enter upon the mining of that area several months before Pearson visited it, and that in a small way, coal had been mined there for 14 years prior to Pearson's visit.

The evidence was clear, the pleading was direct and conclusive, the instructions and charge of the judge were lucid and sufficient, but the jury failed to agree and were discharged. It is said the case will be retried.

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Yours truly
George M. Dawson

THE AMERICAN GEOLOGIST,
VOL. XXVIII. PLATE IX.

THE
AMERICAN GEOLOGIST.

VOL. XXVIII. AUGUST, 1901. No. 2.

GEORGE MERCER DAWSON.

PORTRAIT.

The widespread expressions of deep regret and personal loss following the death of Dr. G. M. Dawson show that his was no ordinary life. Called away while in his prime, and with a past which gave promise of great achievements yet to come, he has left a blank which will not soon be filled.

Dr. Dawson was the second son of the late Sir J. W Dawson, and was born on the 1st of August, 1849, in Pictou, Nova Scotia. In 1855 his father, who had for some years been acting as Superintendent of Education for Nova Scotia, received the appointment of principal of McGill University, Montreal, and with his family took up his residence there. Instead of the magnificent structures of to-day there were then on the college gounds only two "unfinished and partly ruinous buildings, standing amid a wilderness of excavators' and masons' rubbish, over-grown with weeds and bushes. The grounds were unfenced and pastured at will by herds of cattle, which not only cropped the grass, but browsed on the shrubs, leaving unhurt only one great elm, which still stands as the 'founder's tree,' and a few old oaks and butternut trees."* Surroundings of this kind were not ideal from a university point of view, but made a delightful environment for an intelligent boy. The numerous wild flowers, the birds' nests, the fossil shells in the blue clay, the waste waterway where leaves and twigs became "petrifactions," the lively brook where mimic fleets could be navigated and dams constructed—these and many other objects of interest were there, and with the guidance and encouragement of an ever-ready father, the boy's inborn love of nature was daily stimulated and increased.

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*Fifty years of work in Canada—Autobiographical notes by SIR WILLIAM DAWSON, p. 98.

At ten years of age Dawson entered the Montreal High School, remaining there for one year, and taking a high place in his classes. Subsequently, however, owing to ill-health, his education was carried on for the most part under tutors; and while this system no doubt cut him off from some advantages, it gave him on the other hand wider opportunities for pursuing and mastering subjects which had special attractions for him. Surrounded by books, chemical apparatus, paints and pencils, the days were never too long, and photography, book-binding, painting magic lantern slides, and even cheese-making, afforded him fascinating occupation and amusement. One who knew him well at that time says: "He seemed to absorb knowledge rather than to study, and every new fact or idea acquired was at once put into its place and proper relations in his orderly mind. He was always cheerful, amusing and popular, other boys flocking round him and invariably submitting to his unconscious leadership."

At the age of eighteen Dawson entered McGill College as a partial student, attending lectures on English, chemistry, geology, &c., during the session of 1868-9. While a student at this time he wrote a poem on Jacques Cartier which, while but a boyish effort, was thought very well of by his instructors and gave evidence of his keen love of nature and poetic instinct. The view from the summit of Mount Royal, whither Cartier was conducted by the red men of Hochelaga, is thus described:

"Far on the western river lay,
Like molten gold, the dying day.
Far to the east the waters glide
Till lost in twilight's swelling tide;
While all around, on either hand,
Spread the broad, silent, tree-clad land;
And in the distance far and blue
Long swelling mountains close the view."

The following year Dawson went to London and entered the Royal School of Mines, at that time on Jermyn street. He was fond of the sea, and on this occasion made the passage in a sailing ship, he and another young man being the only passengers. During the voyage he amused himself making observations on the surface life of the ocean, and the phenomena of phosphorescence. He also studied navigation, under the direction of the captain, and the knowledge then acquired afterwards stood him in good stead when he had to navigate a schooner along the dangerous coast of British Columbia and the Queen Charlotte Islands.

At the School of Mines he took the full course of study, extending over three years, and passed as an associate. At the end of his second year he carried off the Duke of Cornwall's scholarship, given by the Prince of Wales, and on graduation stood first in his class, obtaining the Edward Forbes medal and prize in Palæontology and Natural History, and the Murchison medal in Geology. While at the School of Mines he paid special attention to the study of geology under Ramsay, Huxley, and Etheridge, but also devoted much time to chemistry and metallurgy, under Frankland and Percy respectively, and to mining, under Warrington Smyth. Even in his holidays he was never altogether idle, and during most of the summer of 1871 he was attached to the British Geological Survey, and worked with the late J. Clifton Ward in the Cumberland Lake district. While in England he made many warm friends, with some of whom he corresponded regularly for years afterwards.

On returning to Canada in 1872 he was engaged for some months examining and reporting upon mineral properties in Nova Scotia, and subsequently went to Quebec, where he delivered a course of lectures on chemistry at Morrin College, which was attended by a large and appreciative class. In 1873 he was appointed geologist and botanist to Her Majesty's North American Boundary Commission, which had been constituted to fix the boundary line between British North America and the United States, from the Lake of the Woods to the Rocky mountains, and which had been carrying on its labours for about a year. From early boyhood Dawson had been keenly interested in travel and exploration, and in the Canadian North West he saw a region ready to yield up a rich harvest of discovery. There was the charm of novelty afforded by a well-nigh untrodden field, and the many hardships to be encountered only seemed to lend attractions to the expedition. In those days no Canadian Pacific trains rolled across the continent. Fort Garry, now the fast-growing city of Winnipeg, with more than 40,000 inhabitants, was then practically the last outpost of civilization, and the great prairies had to be traversed on horseback or on foot, provisions and equipments of every kind being carried in Red river carts, drawn by oxen or ponies, with shaganappy harness. The two years of Dawson's connection with the Boundary Commission were for him years of incessant activity, but the results of his work were of great scientific value. They were embodied in a report addressed to the head of the commission, major (now general) D. R. Cameron, R. A., and published in Montreal in 1875.* The volume, which is now looked upon, as "one of the classics of Canadian geology," is a model of what such reports should be—scientific facts being clearly and succinctly stated and the conclusions logically drawn. The main geological result arrived at was the examination and description of a section over 800 miles in length across the central region of the continent, which had been previously touched upon at a few points only, and in the vicinity of which a space of over 300 miles in longitude had remained even geographically unknown. The report discussed not merely the physical and general geology of the region, and the more detailed characteristics of the various geological formations, but also the capabilities of the country with reference to settlement. The whole edition was long ago distributed, and the volume is now exceedingly scarce and difficult to obtain. While attached to the Boundary Commission Dawson made large collections of natural history specimens, which were forwarded to England and found a home in the British Museum, as well as at Kew and elsewhere. The British Museum obtained no less than seventeen species of mammals not previously represented in its collections.

More or less in connection with the above work were published papers on the "Lignite Formations of the West," the "Occurrence of Foraminifera, Coccoliths, &c., in the Cretaceous Rocks of Manitoba," on "Some Canadian species of Spongillæ," on the "Superficial Geology of the Central Region of North America," on the "Locust Invasion of 1874 in Manitoba and the Northwest Territories," &c.

When the work of the Boundary Commission was brought to a close, Dawson received an appointment on the staff of the Geological Survey of Canada and began in that connection the long series of explorations of the North West and British Columbia, which brought such great credit to himself and his country. In 1883 he was made an assistant director of the survey, and later, on the retirement of Dr. Selwyn, in 1895, became head of the department, a position which he occupied until the time of his death on the 2d of March last. Throughout his connection with the survey his reports were always of a high order, bearing evidence of his striking powers of observation and deduction. Though thoroughly scientific they always took account of the practical and economic side of geology, and accordingly commanded the attention and confidence of mining capitalists, mine managers and others interested in the development of the mineral resources of the country. When in the field, geology was, of course, the principal object of his investigations, but his wide knowledge of collateral sciences enabled him not merely to collect objects of natural history in an intelligent and discriminating way, and to discuss the flora and faunas of different districts, but also to make important observations on the habits and languages of Indian tribes, to keep continuous meteorological records and to determine latitudes and longitudes. We accordingly find that his reports generally conclude with a series of most valuable appendices, giving special information which could not well be included in the body of the document.

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*Report on the Geology and Resources of the Region in the vicinity of the Forty-ninth Parallel, from the Lake of the Woods to the Rocky Mountains, with lists of Plants and Animals collected and notes on the Fossils.

In an elaborate notice of his report on the Queen Charlotte islands, published in Petermann's Mittheilungen (Vol. 27, 1881), the writer after calling attention to the fact that the report dealt not merely with the geology of the islands, but also with their topography, natural history, climate and ethnology, says: "One is amazed at the rich results which he brought back in all these branches, especially as he had only one assistant, Mr. Rankine Dawson, and remained in the islands only two and a half months, from the 12th of June to the end of August, and that in most unfavourably wet weather."

In addition to his field-books proper he generally kept copious journals which contain much interesting information. He had a habit, too, of jotting down notes and sometimes verses on scraps of paper or on the backs of telegraph forms. In the wilds of British Columbia, for example, he writes:

"Contorted beds, of unknown age,
My weary limbs shall bear,
Perchance a neat synclinal fold
At night shall be my lair.
Dips I shall take on unnamed streams,
Or, where the rocks strike, follow
Along the crested mountain ridge,
Or anticlinal hollow:
Or gently with the hammer stroke
The slumbering petrifaction,
That for a hundred million years
Has been debarred from action.

* * * * * * * *

We can fancy him, too, sitting by his lonely camp fire on the shores of the Pacific and penning the following lines:

"To rest on fragrant cedar boughs
Close by the western ocean's rim,
While in the tops of giant pines
The live-long night the sea-winds hymn,
And low upon the fretted shore
The waves beat out the evermore."

Dr. Dawson's gological work was carried on chiefly in the region of the great prairies of the North West and British Columbia, but he was thoroughly informed as to the geology of all parts of the Dominion. In the North West he paid particular attention to the relations of the Cretaceous and Laramie formations; and he discovered the presence in the Cretaceous of southern Alberta of an important series of rocks—the Belly River group—which, he says, "must be considered on the whole as a fresh-water formation. The Kootanie group was also recognized by him as constituting a portion of the early Cretaceous in the Rocky Mountain region. His study of a large area in the interior plateau region of British Columbia established the existence there of a great series of mica-schists and gneisses supposed to be of Archæan age and succeeded by Cambrian, Ordovician, Silurian and Carboniferous strata; while in the Cordilleran region of the same province he described the occurrence of great deposits of contemporaneous volcanic rocks, in various stages of metamorphism. While working in connection with the Boundary Commission also, he studied the crystalline rocks in the Lake of the Woods district, and concluded that a considerable portion of the Huronian formation there consists of metamorphosed volcanic rocks.

He was a careful student of glacial phenomena and according to Dr. G. J. Hinde,* was the first to describe the glacial origin of the Missouri Coteau, and in the interior of British Columbia he has shown that at one period of the Ice age there was a confluent ice-mass, the surface of which stood at a level of 7,000 feet above the sea, and that it must have been at least from 2,000 to 3,000 feet in thickness. He has further established the fact that the movements of the glacier ice in this region were not only to the south and south-east, and through the transverse valley and gaps of the Coast ranges to the ocean, but that it had also a northerly flow, and passed down the valleys of the Pelly and Lewes branches of the Yukon river. Dr. Dawson also maintained that the northern part of the great plains had been submerged, and that their glaciation was in the main due to floating ice.

With regard to his ethnological work we cannot do better than quote from Mr. W. J. McGee's recent appreciative notice in the *American Anthropologist.* Mr. McGee says: "While several of Dr. Dawson's titles and the prefatory remarks in some of his papers imply that his ethnological researches were subsidiary to his geologic work, and while his busy life never afforded opportunity for monographic treatment of Canada's aborigines, it is nevertheless true that he made original observations and records of standard value, that much of his work is still unique, and that his contributions, both personal and indirect, materially enlarged knowledge of our native tribes. It is well within bounds to say, that in addition to his other gifts to knowledge, George M. Dawson was one of Canada's foremost contributors to ethnology, and one of that handful of original observers whose work affords the foundation for scientific knowledge of the North American natives."

Dawson's most notable contribution to ethnology was undoubtedly his memoir on the Haida Indians of the Queen Charlotte islands, but he also published "Notes on the Indian Tribes of the Yukon District and Adjacent Northern Portion of British Columbia," a valuable memoir entitled "Notes and Observations of the Kwakiool People of Vancouver Island," "Notes on the Shuswap People of British Columbia," and other papers.

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*Geological Magazine, May, 1897.

When, in 1884, the British Association appointed a committee to study the physical characters, languages and social conditions of the northwestern tribes of Canada, Dr. Dawson was made a member, and it devolved upon him to organize and administer the work of the committee. The work was carried on for years with much success and small money expenditure, and when, in 1896, an Ethnological Survey of Canada was instituted, Dawson was chosen as the head of the survey committee.

Not the least of his services to his country were those in connection with the Behring sea arbitration. He was one of the commissioners and was sent by the British government to the north Pacific ocean to inquire into the conditions of seal life there. Subsequently, his evidence and forcible arguments undoubtedly secured for the British side of the case a much more favourable finding than would otherwise have been obtained. Lord Alverstone (now Lord Chief Justice of England) writing of him in this connection, says: "It is not possible to overrate the services which Dr. Dawson rendered us in the Behring sea arbitration. I consulted him throughout on many questions of difficulty and never found his judgment to fail, and he was one of the most unselfish and charming characters that I ever met. I consider it a great pleasure to have known him." In recognition of his services on the arbitration, Dr. Dawson was made a companion of the Order of St. Michael and St. George (C. M. G.).

He received the degree of D. Sc. from Princeton in 1877, and that of LL.D. from Queen's University in 1890, from McGill University in 1891, and from Toronto University some years later. In 1891 he was awarded the Bigsby gold medal by the Geological Society for his services in the cause of geology, and was also elected a Fellow of the Royal Society. In 1893 he was elected president of the Royal Society of Canada, and in 1897 was president of the geological section of the British Association for the Advancement of Science at the Toronto meeting. In 1897 he was awarded the gold medal of the Royal Geographical Society. Last year he was president of the Geological Society of America, and gave his retiring address at the Albany meeting in December, choosing as his subject "The Geological Record of the

Rocky Mountain Region in Canada." This address was published as a bulletin of the Geological Society of America, and will be prized as giving a summing up of his latest views on some of the problems connected with the complex geology of the west. Many other distinctions, which cannot be enumerated here, fell to his lot, and he had won for himself the esteem and confidence of his fellow-countrymen in all parts of the Dominion. Nowhere was he more beloved than in British Columbia—the province in which he had done so much of his best work, and in which, he sometimes said to the writer, he would like to spend his last days.

After the Toronto meeting of the British Association in 1897, he accompanied a party of the members on a trip across the continent, and all were struck with the warmth of the welcome everywhere accorded to him. "Among the many distinguished visitors," writes the *Victoria Colonist*, "by whose presence Victoria has been honored during the past few days, none holds a higher or more deserved place in the esteem of Canadians than George M. Dawson. In one sense he is the discoverer of Canada, for the Geological Survey, of which he has been the chief, has done more than all other agencies combined to make the potentialities of the Dominion known to the world. He has been engaged in the work so long that he can look back over it with the profound satisfaction which comes from the knowledge that his judgment on points of extreme interest and value has been justified by events. The development of Kootenay, the hydraulic mines of Cariboo, and the gold mines in the Yukon are all foretold in the interesting pages of Dr. Dawson's earlier reports. Therefore, when we find in the voluminous products of his pen, wherein the results of his observations are recorded, anticipations of great mineral development in parts of the province that are as yet unexplored, we feel almost as if such development were guaranteed. A careful observer, a conservative reasoner, a skilful writer, Canada possesses in Dr. Dawson a public servant the value of whose services can never be over-estimated. His name carries authority with it on any subject on which he speaks. That a long career may be before him is the hope of all, for we all know how much that means to the Dominion."

Dr. Dawson was a ready and prolific writer and a brilliant conversationalist. His quiet humour was infectious, and any dinner party which numbered him among the guests was sure to be a merry one. He seemed to have an inexhaustible fund of information, not merely about his own special lines of work, but covering the widest range of subjects. The marvel was how in his busy life he had acquired so much and such varied knowledge. For one of apparently delicate constitution his powers of enduring prolonged physical exertion were as remarkable as his capacity for continuous mental activity. He was at work at his office until two days before his death, the immediate cause of which was capillary bronchitis. The secret of Dr. Dawson's widespread popularity, no doubt, lay in his downright unselfishness and in his sunny and sympathetic nature.

B. J. H.

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THE PLEISTOCENE PROBLEM OF THE NORTH ATLANTIC COSTAL PLAIN.*

By George Burbank Shattuck, Baltimore, Md.

In that portion of the Atlantic Coastal Plain which lies between the Raritan and Potomac rivers there is a mantle of loam, sand and gravel covering most of the earlier deposits of the lowland and lapping well up on the Piedmont Plateau. This veneer of unconsolidated deposits has long attracted the attention of explorers and various opinions regarding its relations and structure have been entertained. The attention of the earlier geologists was largely taken up in unravelling the history of the more attractive crystalline and fossil-bearing rocks, and in problems connected most intimately with glaciation, and it was not until Mr. W. J. McGee, formerly of the United States Geological Survey, undertook the study of these superficial deposits that their true relations began to appear. The conclusions on this subject which Mr. McGee has published from time to time during a period of fourteen years may be briefly summarized as follows:

VIEWS OF MR. W. J. M'GEE.

The Lafayette, which is a series of orange-colored loams, sands and gravels, extends up, according to Mr. McGee, from the south and occupies the divides and higher portions of the Coastal Plain of Virginia as far north as Fredericksburg. Distinct from these deposits both in origin and age, is another series of loams, sands and gravels designated by him as the Columbia formation, which fill the valleys of the present streams and mantle the divides between them. This formation is divisible into two phases, fluvial and inter-fluvial. The fluvial phase is composed of deltas which were deposited under water, by those streams in whose valleys they now lie, when the land stood lower than it does today. The inter-fluvial phase is found on the divides and is a littoral deposit made by the waves which beat against the coast at the same time the rivers were building their deltas. The two phases are therefore contemporaneous and grade over into one another. The fluvial phase exhibits a distinct bi-partite division. The upper member consists of a brick-clay and loam, and the lower member is

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*From the *Johns Hopkins Circulars*, No. 152, May, 1901.

composed of sand, gravel and huge boulders. The material as a whole, is coarser near the mouths of the gorges where the rivers leave the Piedmont Plateau to pass into the Coastal Plain than it is in the more remote portions of the delta. The interfluvial phase possesses no such regularity of bedding, but is indiscriminately composed of clay, sand and gravel largely of local origin. These delta deposits may be identified in all the principle rivers of the Middle Atlantic slope and are particularly well developed in the valleys of the Potomac, Susquehanna and Delaware. Due to the presence of these huge boulders, which were evidently ice-born and indicate a climate much colder than exists today in the same region, as well as to the fact that the Columbia, when traced northward, is found to pass under the terminal moraine, it was concluded that it was Quartenary in age and belonged to the earlier glacial advance. These beds, since their deposition, have been raised and tilted so that they now lie higher in the regions to the north than they do further south. Their present elevation was found to be about 500 feet on the upper Susquehanna and 245 feet at its mouth; 400 feet on the upper Delaware; 145 feet on the Potomac; 125 feet on the Rappahannock; 100 feet on the James and 75 feet on the Roanoke.

Mr. McGee also noted certain well-defined terraces which were distributed over the entire region, and spoke of them as follows:*

"There is a practically continuous series of terraces and beach marks along the fall line from the Roanoke to the terminal moraine—a series of shore lines as distinctive and unmistakable as those circumscribing the valleys of the extinct lakes of the Great Basin, of India, of northern Arabia, or of the partially ice-bound basins of Minnesota, Michigan, Ohio and New York, though they are generally more profoundly modified by erosion, and are frequently concealed by forests. These shore lines embody an easily interpreted record of geologic vicissitude which coincides in every detail with that of the Columbia deposits. They are sometimes carved out of the sub-terrane but are generally built of the loam, sand and gravel of which the Columbia formation consists, and are evidently coeval therewith. Now it is evident that these terraces are water fashioned; but they are not fluvial. * * * The forces concerned in the formation of the Middle Atlantic slope terraces acted horizontally over great distances and with uniform energy for a considerable period, filling depressions, softening contours, and obliterating relief, yet so gently that essential homogeneity of deposit in the horizontal direction and essential uniformity in surface prevails for miles. Only the undulatory and horizontally acting force of waves appears competent to produce so great expanses of uniform surface and constant structure as are exhibited in this region."

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*Amer. Jour. Sci., Vol. 35, 1888, pp. 387-388.

A summary of Mr. McGee's views regarding the various land movements as expressed by the present state of the Lafayette and Columbia deposits is as follows:

Post-Chesapeake,	elevation and erosion.
Lafayette (Pliocene?),	depression and deposition.
Post-Lafayette,	elevation and erosion of at least 500 feet; present topography defined.
Early Columbia (Pleistocene),	depression of about 200 feet and deposition.
Post-Early Columbia,	elevation and erosion.
Later Columbia,	depression of about 100 feet and deposition.
Post-Later Columbia,	elevation and erosion.
Present,	depression and deposition.

At the New York meeting of the American Association for the Advancement of Science during the summer of 1900, Mr. McGee took occasion to refer to certain relations of the gravels as developed in the vicinity of Washington. After reviewing briefly the various deposits which occur in that region, he is reported by Mr. J. A. Holmes as making the following statement.*

"In a few localities, especially in the deep cutting in the 200-foot terrace at the end of Sixteenth street, deposits have been observed which fail to fit into this series. This cutting reveals, unconformably beneath the Earlier Columbia and unconformably above the Potomac, a heavy deposit of loam and gravel of a structure, composition, texture and material simulating the Earlier Columbia formation in its normal aspect, save that the materials are more extensively disintegrated and decomposed. The resemblance of the deposit to the Earlier Columbia is such that it might readily be classed with that

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**Science*, n. s., Vol. xii, 1900, pp. 990-991.

formation if found isolated; but in the Sixteenth street exposure the two deposits are juxtaposed and separated by a well-defined unconformity—i. e., the stratigraphy shows that the deposit in question is materially older than the Earlier Columbia. On comparing the deposit with the Lafayette, as displayed in the nearest exposures of that formation on the west, north and east, it is found to be so different in materials and structure as to demand separation on lithologic grounds; moreover, the deposit is confined to a depression, or amphitheatre, which did not exist at the time of Lafayette deposition, but was produced during the period of rapid degradation accompanying the post-Lafayette uplift; so that it must be discriminated from the Lafayette on the basis of homogeny as well as on that of lithology. The interpretation of the deposit is simple: it is evidently a record of an oscillation during the post-Lafayette and pre-Columbia time, which was not of such amplitude and length as to inscribe itself deeply in the local series of formations and land-forms. On seeking to correlate the deposit with other elements in the coastal-plain series, difficulty is encountered; no corresponding deposits are known either southward or eastward in Virginia and Maryland; the nearest known deposits of corresponding character and position are a part of those found in southern New Jersey, and first grouped by Salisbury under the designation Pensauken, but afterward divided."

Pressure of other duties prevented Mr. McGee from continuing the investigations which he had so happily commenced, and Mr. N. H. Darton, of the United States Geological Survey, took and carried forward the work where Mr. McGee left it.

VIEWS OF MR. N. H. DARTON.

According to Mr. Darton, the Lafayette formation does not end at Fredericksburg, but in disconnected areas, crosses Maryland, Delaware and Pennsylvania, into New Jersey. In this connection he said:* "The northern termination of the deposits was supposed to be near Potomac creek, a few miles north of Fredericksburg; but I have found that while there is a break in its continuity in the region east of the Potomac river, it soon begins again and thence continues northward probably through Maryland, and in attenuated scattered outcrops, through Delaware and into Pennsylvania and New Jersey. It is displayed in the high terraces about Washington, and it caps nearly all the higher terrace levels of the "western shore" of Maryland northward to the latitude of Baltimore. Still farther northward it is confined to outliers on the divides along the western margin of the coastal-plain region; but at the head of Chesapeake bay it extends farther eastward and, in the high Elk ridge, caps the Cretaceous and Potomac formations over a considerable area."

The Lafayette was also described as continuing down the peninsulas of the Coastal Plain.† In this connection he said: "I have found that the formation extends eastward down the coastal plain peninsulas nearly to Chesapeake bay. These peninsulas consist of remnants of an elevated plain, occupied by a sheet of Lafayette formation, and originally continuous over the entire coastal plain. This plain is inclined gently eastward, its altitude decreasing from 500 feet in the Piedmont region, to from 60 to 80 feet in the vicinity of Chesapeake bay, where it is terminated by an abrupt descent to the low Pleistocene terrace bordering the bay to a width of several miles."

The Columbia of Mr. McGee is found by Mr. Darton to be divisible into an earlier and a later member, which are developed in well-defined terraces, the former lying normally above the latter. The land surfaces upon which the Lafayette and Columbia terraces were deposited has been raised and tilted at various times in such a manner that only in that part of the Coastal Plain which lies near the Piedmont was the normal sequence present, while in that portion bordering on Chesapeake bay the normal sequence was reversed. This state of things was brought about in the following way: At the close of the Lafayette deposition, the surface on which that formation rested was raised and tilted so as to slope eastward toward the sea, and after suffering considerable erosion, it was depressed in such a manner that its eastern portion was submerged while its western margin bordering the Piedmont Plateau remained above water. In the estuaries thus formed and along the coast, the earlier Columbia formation was then deposited. This formation, therefore, built up a terrace below that of the Lafayette in the heads of the estuaries near the Piedmont, but covered up the Lafayette surface where it was submerged to the east. While the deposition of the earlier Columbia was still in prog-

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Bull. Geol. Soc. Amer., Vol. ii, 1891, p. 445.

†*Amer. Geol.*, Vol. ix, 1891, p. 181.

ress, the Coastal Plain again tilted so as to bring that portion of it lying to the northeast and against the Piedmont above water, while the southeastern portion was still further depressed. The later Columbia was in its turn deposited in the estuaries beneath the earlier Columbia where the latter had been elevated, and above it where it had been depressed. Consequently the three formations near the Piedmont were developed in separate terraces lying one above the other, the Lafayette at the top, with the earlier Columbia in the middle and the later Columbia at the bottom, while in the eastern submerged portion the formations were not developed in terraces, but in a continual series, with an erosive break between the Lafayette and the earlier Columbia. In this region the sequence ran, beginning at the top, later Columbia, earlier Columbia, and Lafayette.

Mr. Darton has published a number of geologic maps from time to time in which these relations are depicted. In an early map of the Washington region, he included only two formations of gravel, the Lafayette and Columbia, but in a later and revised edition, which is now in the press, and which he has been kind enough to show me, three formations of gravel are portrayed, the earlier and later Columbia and Lafayette, developed in distinct terraces, lying one above the other as described. The Nomini and Fredericksburg folios of the Geologic Atlas of the United States convey his ideas regarding the sequence of gravel in portions of southern Maryland and eastern Virginia. In these publications he distinguishes two gravels lying in distant terraces, the Lafayette above, covering the divides, and the Columbia beneath, occupying the valleys.

VIEWS OF PROFESSOR R. D. SALISBURY.

Professor R. D. Salisbury commenced his work on the detailed survey of the Pliestocene deposits of the Coastal Plain of New Jersey in the summer of 1891. In his first report* he mentions a number of peculiar deposits bearing glaciated boulders which he states were somewhat like till in character. The following is quoted from the Report of the State Geologist of New Jersey for 1891, page 107:

"Drift, closely resembling till and containing striated rock material, occurs on the west side of the Delaware, near Falls-

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***Annual Report of the State Geologist of New Jersey* for 1891.

ington, three or four miles southwest of Trenton * * * the writer found similar deposits at Bridgeport, Pa., opposite Norristown, still further south. * * * Glaciated boulderets were here taken from clay of such character that, were the locality known to have been covered by ice, its reference to till would be fully warranted. Bridgeport is about 50 miles south of the terminal moraine.

"It is not intended to convey the impression that every region where glaciated stone may be found was necessarily once covered by glacier ice. The possibility of transportation of glaciated material beyond the edge of the ice by water, is distinctly recognized. But it is not believed that water alone, or water-bearing glacially-derived bergs could produce all the results which are here recorded. Neither the structure of the extra-morainic drift, nor its physical make-up, nor its geographic or topographic distribution, is consistent with such a hypothesis.

"At several points in New Jersey south of all the localities thus far mentioned within the state, there are topographic features which are easy of explanation if ice once extended to the region where they occur, but which seem to be very difficult of explanation on any other hypothesis. The features here referred to characterize the region from Washington, Middlesex county, southwest to Fresh ponds and beyond, and also the region east of Trenton, from White Horse to Hamilton square. The topography in these regions is very much like that of a subdued terminal moraine."

In his report for 1892, professor Salisbury discusses at some length the character and origin of the Trenton gravel; he shows very plainly that it was a valley train deposited by the Delaware river from materials washed from the glaciated regions, and states that it was deposited "during that stage of glaciation when the ice edge stood near Belvidere." He then discusses the Yellow Gravel formation of professor Cook and shows that it recorded a most complex history. His conclusions may be summarized as follows:

First. "The time of deposition of the original yellow gravel." This covers the period when the country was sufficiently low to allow the gravel to accumulate on hills which are now nearly 400 feet high, at least south of Matawan. Age pre-Pleistocene.

Second. "An epoch of elevation and extensive erosion. This covers a period when the yellow gravel was raised and the land surface greatly eroded.

Third. "An epoch of depression." This embraces a period when central and southern New Jersey was 150 feet lower than now. This depression is correlated with the first glacial epoch and is also tentatively correlated with the Columbia.

Fourth. "An epoch of elevation and erosion." During this time the land was raised to a greater hight than before and the streams cut deeper valleys than during the early epoch of elevation.

Fifth. "An epoch of slight depression." Correlated tentatively with the last glacial epoch and also was the period when communication was established between Raritan bay and Trenton.

Sixth. "Subsequent elevation." An elevation of 40 to 60 feet followed by the present subsidence.

Professor Salisbury in his report for 1893 divides the yellow gravel for the first time into four well-defined periods: the first and the oldest he calls the Beacon Hill; the second, Pensauken; the third, Jamesburg; and the fourth is left unnamed, but later, in a subsequent publication, is called Cape May.

The Beacon Hill formation appears to be Miocene, and therefore, will not enter further into our discussion of the gravels.

According to professor Salisbury, the Pensauken was deposited in valleys cut out during the post-Beacon Hill elevation. It is considered to be an aqueous formation, and its distribution indicates that the land was submerged 200 feet during its deposition. One of the chief diagnostic features of this formation is the presence of decomposed boulders of gneissic and granitic material found imbedded in its mass. The formation ranges in elevation from 200 feet at Perrineville to 80-90 feet south of Palmyra. The elevation is also regarded as being more in the region of Beacon Hill than elsewhere. At South Amboy its presence is indicated at an elevation of 147 feet.

The name of the formation is derived from Pensauken creek, but the statement is made that the formation is most characteristic near South Amboy, and that the latter locality would have been chosen to typify the formation were it not for its association with the plastic clays.

In the report for 1894 professor Salisbury points out that a submerged trough formerly existed in central New Jersey extending from Raritan bay to Delaware bay, allowing a communication between these two bodies of water and separating southeastern New Jersey from the mainland as an island. In this trough were deposited the Pensauken and Jamesburg formations and the Trenton gravel. Various elevations of the Pensauken are also mentioned in this report. The most noted differences in elevations are the following: at Fish House, the elevation of the Pensauken is stated as 15 feet where it lies immediately under the Fish House clays, the latter being regarded here as post-Pensauken. Nine miles southeast of Fish House, the base of the Pensauken is at an altitude of 150 feet, thus making a rise of 15 feet per mile. Professor Salisbury also reaffirmed the deformation of the Pensauken surface since its deposition. The age of the Pensauken is ascribed to the Lafayette in the following terms: "There can no longer be any doubt that the Pensauken is the equivalent of the Lafayette formation of the south. This conclusion was reached tentatively more than a year since."

In the report for 1895 professor Salisbury points out that the base of the Pensauken formation rises to the southeast in harmony with the Miocene and also inclines toward Delaware river. He also somewhat doubtfully refers the Fish House clays to the Pensauken. The Pensauken formation [illegible] trough extending from Raritan bay to the Delaware [illegible] well as the Pensauken [illegible] eastern bank of the Delaware are [illegible] large body of gravel [illegible] adelphia to Atlantic [illegible] stated in the report [illegible] clear his conception [illegible] marked difference [illegible] lowest position near [illegible] in the vicinity of [illegible] count for this [illegible] are suggested, such as [illegible] bifold division of the [illegible] says: "From [illegible] sauken might be [illegible] the whole as Pensauken, for he further says: "Indeed, on any interpretation, the original continuity of the Pensauken across this belt seems certain, for occasional small remnants of it are still found."

In the report for 1896, professor Salisbury no longer regards the Pensauken as being equivalent to the Lafayette, but places it in early glacial time. On the Mt. Pleasant hills he states the Pensauken formation probably lies as high as 178 feet, and suggests that these gravels may be a landward deposit of Pensauken streams.

He also places in the Beacon Hill formation the topographically higher member of those gravels found in the vicinity of Glassboro which, in the previous year, he had regarded as Pensauken. He also publishes a map and a section where this change in classification is recorded. The southward dip of the Pensauken is reaffirmed and the statement is made that the base of the Pensauken formation at times extends down below tide.

In the report for 1897, professor Salisbury publishes a map in which he again changes his classification in southern New Jersey. The high gravels occurring in the vicinity of Glassboro, which he had first mapped in 1895 as Pensauken, and later in 1896, as Beacon Hill, he now places in three distinct formations, namely: Miocene, Beacon Hill, and Bridgeton; the Beacon Hill being younger than the Miocene, and the Bridgeton younger than the Beacon Hill but older than the Pensauken. In this connection he says: "The differentiation of the Bridgeton formation has been long in mind, though data for its sharp definition have been wanting. Even now they cannot be said to be altogether satisfactory. In some places the formation seems not to be clearly separable from the Beacon Hill formation which preceded, while in others it is not easily distinguished from the Pensauken which follows. In other places, on the other hand, it is distinctly separable from the Pensauken, and in still others from the Beacon Hill. The only question, therefore, concerns the integrity of the formation as a whole, and the data at hand do not demonstrate that that part of the formation which seems to be closely allied to the Beacon Hill formation is not really a part of that formation, and that that part which is with difficulty separated from the Pensauken, is not really Pensauken. On the other hand, these two parts, the one of which seems to have affinities with the Beacon Hill formation and the other with the Pensauken, seem to belong together. * * * *

"In general it (Bridgeton) may be said to contain any sort of material which the Beacon Hill formation contains, and some which it does not. It is therefore most clearly separated from the next older formation by its constitution. But occasionally its constitution closely approaches that of the Beacon Hill formation, and where its topographic relations are at the same time indecisive, its differentiation is uncertain.

"From the Pensauken, on the other hand, it is most clearly separated on topographic grounds, especially in the western part of the state. Here the Bridgeton beds lie at a level distinctly above that of the Pensauken beds, the latter being restricted to the low area west of the Miocene escarpment. The topographic relation of the formations indicates a long interval of erosion between their deposition. * * * *

"Some idea of the former extent of the Bridgeton beds may be gained if all existing remnants of it be conceived to be extended until they merge into one another, bridging the areas intervening between the existing remnants. It is believed that the formation extended much less far north than that which preceded, though the original limits are probably not determinable.

"It is altogether possible that some of the areas mapped as Bridgeton, west of the New Jersey Southern railway, may prove to be Beacon Hill instead, and that some of the areas east of that line may prove to be Pensauken. The distinction in the latter area is based almost wholly on topographic grounds." He again mentions a tilting of the Pensauken formation and correlates the Pensauken with Kansan or Albertan.

A Pleistocene formation much discussed by professor Salisbury in New Jersey is the Jamesburg.

His conclusions regarding the Jamesburg formation may be briefly stated as follows: In the report of 1893, it appears that the Jamesburg was deposited on the eroded surface of the Pensauken. It is aquatic in origin, and the subsidence which made possible its deposition amounted to at least 130 feet. The name is derived from Jamesburg Junction, in Middlesex county. A difficulty is encountered, however, in the absence or obscure-ness of a shore line for the Jamesburg sea. The material making up the Jamesburg formation is very much like that going to make up the Pensauken. Professor Salisbury states: "In some places the weathering of the latter (Pensauken) might have given rise to the overlying bed, which is here classed as Jamesburg." He states that there is in the Jamesburg an absence of the materials which in the Pensauken are decomposed, such as granites, gneisses and schists, as well as the Triassic shales and sandstones, which are commonly found in the Pensauken. The age of the Pensauken is made equivalent to that of the Columbia or a part of it, for he said: "The Jamesburg is, therefore, but a local name for the Columbia formation, or for a part of it." It is correlated with an early glacial epoch, and Trenton and Trenton Junction are given as excellent localities for the Jamesburg.

In his report for 1894, professor Salisbury regards the Jamesburg as a mantle, covering the country up to 214 feet or more. He considers it corresponding in a general way to the high-level and low-level Columbia, but that the Columbia of the south is believed to include more than the Jamesburg of New Jersey. The Jamesburg not only covers the bottom, but is found lapping up on the sides of the trough between Raritan bay and the Delaware river with a distribution as wide as that of the Pensauken. It is unconformable on the latter and on older formations. Near Cream Ridge, the Jamesburg is stated as occurring at 214 feet and near Marlton 180 feet.

The Jamesburg is now divided into high-level and low-level Jamesburg. The relations of the high-level Jamesburg are very obscure, the low-level Jamesburg seems somewhat easier to recognize. In regard to the high-level Jamesburg, professor Salisbury says: "The high-level Jamesburg is often very thin. Where it rests on the Pensauken it frequently has the appearance of being but the weathered part of the latter, so that it is often very difficult to distinguish between them on lithological grounds. So true is this that study had been long in progress before the existence of the 'high-level' Jamesburg over the higher areas of the Pensauken was regarded as demonstrated. The great body of facts now in possession, however, has put the existence of this phase of the formation beyond question. This statement is made with full recognition of the fact that good observers might see scores of sections of Jamesburg and Pensauken, the one over the other, without suspecting a subdivision unless attention was especially directed to the matter. Even then it is probable that nine sections out of ten, or perhaps forty-nine out of fifty, would fail to be convincing on lithological grounds. But the tenth section or the fiftieth is conclusive, and carries the other nine or forty-nine with it."

The Jamesburg is poorly stratified and often contorted as if by lateral pressure. The limits of the high-level Jamesburg are upwards of 214 feet, and the low-level Jamesburg are 45 feet, the latter being deposited in rude terraces. The surface of the Jamesburg is pointed out as being frequently marked with low-ridges and saucer-like depressions. The low-level Jamesburg is considered in part at least younger than the high-level Jamesburg.

In the report for 1895 professor Salisbury states that the Jamesburg formation is very difficult to distinguish, and its existence has been called in question in many places. In this connection he says: "It should perhaps be stated that the existence of the Jamesburg has been called into question at many points. Lithologically it so closely resembles what might be produced from the weathering of the underlying beds, that at many points and over considerable areas, its existence could not be affirmed on the basis of facts there represented. But there are various points, on the other hand, and these widely distributed, where the Jamesburg formation is represented by a thin stratum, which could not by any possibility have been derived from the underlying formations, and the certain presence of the Jamesburg in such places is sufficient to carry the doubtful areas so situated that they cannot have escaped the influence of the agencies which made the deposits about the interpretations of which there is no doubt." He also states that the low areas about the coast are probably low-level Jamesburg, and are equivalent to the low-level Columbia, and in part contemporaneous with the Trenton gravel.

In the report for 1896 under the head of Post-Pensauken submergence, professor Salisbury mentions the 40-foot terraces, and also terraces as high as 200 feet on the Mt. Pleasant hills, as being deposited by streams which emptied into the

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sea, when the 40-foot terrace was being formed, and therefore the up-stream portion of the 40-foot terrace.

In 1897 the Cape May formation is defined as developed in terraces running from 30 to 50 feet in hight. It is regarded as part glacial and perhaps in part younger. It is named from Cape May county, New Jersey, where it is typically developed and is regarded as including much of the low-level Jamesburg, and also much of the Trenton gravel.

The high-level Jamesburg (High-Level Loam) is still recognized, but the statement is made that it cannot be mapped. Professor Salisbury suggests that the high-level Jamesburg is a part of the Cape May formation, and represents a brief subsidence of the Coastal Plain of that region, amounting to 200 feet or more, at the close of the last glacial period. He also states that the formation is very hard to distinguish and difficult to be sure of.

A later view was expressed by professor Salisbury on December 28, 1900, when in the course of official correspondence with the Maryland Geological Survey, he said: "You will notice that in the later reports I have not used the word Jamesburg * * * I now regard it as a phase of the Cape May formation."

VIEWS OF THE WRITER.

For a number of field seasons, the author of this paper has been engaged in the investigation of the surficial deposits of Maryland. Reconnoissance work has been extended over the entire Coastal Plain, and a number of counties have been already mapped in detail. In pursuing these investigations, he has made free use of the methods of homogeny, and the correlation of the deposits thus established has necessitated not only the introduction of some changes in the classification and interpretations as suggested by Mr. Darton, but also has shown that the classification adopted by Prof. Salisbury for the New Jersey area is in no measure applicable to Maryland.

The key to the solution of the relations existing between the surficial deposits of Maryland lies almost exclusively, according to the author, in a correct correlation of the various terraces in which they are developed throughout the Coastal Plain. In Maryland, five principal terraces are distinguished, lying one above the other, the oldest occupying the highest and the youngest, the lowest portions of the region. Beginning with the oldest and enumerating them in succession, we have what the author has designated as the Lafayette, Sunderland, Wicomico, Talbot and Recent. The Recent terrace is the one which the present sea is building.

A correct understanding of the physiographic features of the terraces may be obtained by studying the manner in which this recent terrace is forming. At the present time the waves of the Atlantic ocean and Chesapeake bay are engaged in tearing away the land along their margins and in depositing it on a sub-aqueous platform or terrace. This terrace is everywhere present in a more or less perfect state of development, and may be found not only along the exposed shore, but also passing up the estuaries to their heads. The materials which compose it are extremely variable, depending not only on the detritus directly surrendered to the sea by the land, but also on the currents which sweep along the shore. Along an unbroken coast, then, the material has largely a local character, while near river mouths the terraces are composed of debris contributed from the entire river basin. Where the waves are weak, partially decayed material is torn from the bank and re-deposited practically unharmed on the surface of the terrace, and continues, unchecked, its process of decay.

In addition to building a terrace, the waves of the Atlantic and Chesapeake are cutting a sea cliff along their coast line, the hight of this cliff depending not so much on the force of the breakers as on the relief of the land against which the waves beat. A low coast line yields a low sea cliff and a high coast line the reverse, and the one passes into the other as often and as suddenly as the topography changes, so that as one sails along the shore of the Chesapeake, high cliffs and low depressions are passed in succession. The wave-built terrace and the wave-cut cliff then are constant features along the entire extent of the bay shore, and should be sought for whenever other terrace surfaces are investigated.

In addition to these features, bars, spits and other formations of this character are frequently met with. Were the present coast line to be elevated, the sub-aqueous platform which is now building would appear as a well-defined terrace of variable width with a surface gently sloping toward the water. This surface would fringe the entire Atlantic and bay shore as well as that of the estuaries. The sea cliff would at first be sharp and easily distinguished, but as ages passed the less conspicuous portions would gradually yield to the leveling influences of erosion, such as soil creep, plant roots, cultivation etc., and might finally disappear altogether. Erosion would also destroy in a large measure the continuity of the formation, but as long as portions of it remained the old surface could be reconstructed and the history of its origin determined.

It was with these features well in mind that the author undertook the investigation of the surficial deposits in Maryland, and it was found that they supplied the necessary clue to their interpretation. Without entering into many details it may be briefly stated that the oldest terrace, the Lafayette, is found as outliers on the eastern edge of the Piedmont plateau from Washington across Maryland and Pennsylvania to New Jersey. The elevation of these deposits varies from about 500 feet behind Washington, as determined by Mr. Darton, to about 300 or 400 feet in the vicinity of Philadelphia, where it has long been known as the Bryn Mawr gravel. Besides these outliers of the Lafayette on the Piedmont plateau, there are others on Elk Neck occupying a lower elevation, and still another and more extensive area on the Coastal Plain immediately southeast of Washington. This area has already been reported by Mr. Darton, but it has been found after careful investigation that in place of extending down the peninsula to the Chesapeake bay, it ends in an abrupt low scarp line, which may be seen in the vicinity of Charlotte Hall, in St. Mary's county, and at numerous other localities. No Lafayette is known to exist, however, on the peninsula at Calvert county. The elevation of the Lafayette at this scarp in southern Maryland is about 270 feet.

The next younger formation, the Sunderland, is extensively developed throughout Prince George's, Charles, St. Mary's and Calvert counties, and numerous outliers exist on other parts of the western shore from Herring Bay to Elkton, but the continuity of the formation in this portion of the state has been destroyed. This formation is developed as an unmistakable terrace butting up against the Piedmont plateau or lapping around the edges of the Lafayette. The scarp line at Charlotte Hall is part of the ancient sea-cliff of the Sunderland sea.

The materials composing it are extremely diverse, and embrace ice-borne boulders, gravel, sand and loam, which change their mutual distribution both vertically and horizontally, after the manner of shore deposits. They are frequently much altered and decayed, and have been derived not only from formations occurring in the immediate vicinity, but also from those found far west in the mountains. In southern Maryland the base of the Sunderland terrace lies at about 90 feet, but rises gradually toward the northwest, until at Charlotte Hall the surface of the bench is found at 170 feet. The name of this formation is derived from the hamlet of Sunderland, situated on the divide, in Calvert county.

After the deposition of this terrace, the country was raised and the Sunderland formation suffered greatly from erosion, but on the submergence of the region, the rivers which had found their way across its surface were transformed into estuaries, and the waves of the Wicomico sea beat on the exposed shores of the Sunderland terrace, and in their turn cut cliffs along its margin. After sufficient time had elapsed to build up a wide terrace, the country was again elevated and subjected to erosion.

What has just been said regarding the materials which enter into the Sunderland formation applies equally well to those composing the Wicomico terrace, except that it possesses perhaps a larger proportion of sand and loam derived from its subterrane. In southern Maryland the base lies at about 40 or 50 feet, and the top, where it borders its ancient sea-cliff at about 90 feet. Wicomico river in St. Mary's and Charles counties suggested the name for this formation.

The Talbot formation is developed as a bench of variable width around the edges of the Wicomico terrace, and frequently separated from it in many places by a low scarp line. Occasionally this scarp, which is the ancient sea-cliff of the Talbot sea, attains a hight of 30 to 40 feet, notably in Kent county, but on the other hand, there are localities where the scarp seems to be entirely lacking, and it is probable that in these places it has been destroyed, since its elevation in the manner described above. The Talbot formation was built up during a slight subsidence which followed the elevation and erosion of the Wicomico terrace. Large areas of the Wicomico and Talbot formations have been mapped on the western shore, but it is on the eastern shore of Maryland that they attain their most extensive development.

Any sort of detritus which enters into the other terraces may be found in the Talbot, but it possesses a greater proportion of loam and a smaller proportion of decayed materials than is found in the other members of the series. It also contains numerous lenses of greenish-blue clay, which frequently carry plant remains and are regarded as swamp deposits, formed in the mouths of ponded streams, and buried by the advancing beach of the Talbot sea. The famous Cornfield Harbor clays, carrying remains of marine and brackish water animals, as well as similar deposits five miles south of Cedar Point, in the same county, are also referred to the Talbot formation. The base of the Talbot terrace is irregular, sometimes lying above tide and sometimes below, but the top, where it borders its sea-cliff, is usually limited by the 45 or 50-foot contour.

A large number of terraces are cut in the Wicomico-Talbot surfaces by the streams along whose borders they lie, and it was not until after many profiles from various and distant regions had been compared that the 45-foot contour was determined to be the one which marked the shore of the Talbot sea. The name of this formation is derived from Talbot county, on the eastern shore of Maryland.

After the deposition of the Talbot terrace, the Coastal Plain was elevated somewhat higher than it is today, and remained in that position long enough to permit the rivers which flowed across it to cut rather deep channels, and its present position indicates a subsidence sufficiently great to drown these rivers and many of their predecessors toward their seaward portions. The Recent terrace is today building along the shore, and cutting its sea-cliff indiscriminately in the Talbot, Wicomico and Sunderland formations.

From the preceding discussion it will be seen then that the classification adopted by the Maryland Geologic Survey recognizes four distinct mapable terraces in Maryland, in place of three as represented by Mr. Darton in the region of Washington, and differs from him in ascribing the formation of the divides of the peninsulas of southern Maryland to a formation younger than that of the Lafayette. Although the Wicomico surface rises gradually from an elevation of 90 feet in southern Maryland to about 140 feet behind Philadelphia, yet the distribution of the terraces does not seem to the author to indicate the complicated tilting described by Mr. Dalton, but on the contrary points to the following course of events. Miocene elevation and erosion; subsidence and the deposition of the Lafayette formation; elevation and extensive erosion; subsidence and deposition of the Sunderland terrace around the edges of the Lafayette; elevation and erosion; subsidence and deposition of the Wicomico terrace about the margin of the Sunderland; elevation and erosion; depression and deposition of the Talbot about the margin of the Wicomico; elevation and partial erosion of the Talbot; subsidence and the deposition of the Recent terrace about the edges of the Talbot.

It is interesting in looking at a map of these various terraces to see how repeatedly the present estuaries have been transformed from rivers to fjords and back again to rivers, for one may trace the Sunderland, Wicomico and Talbot terraces up the valleys of all the principal streams to the Piedmont plateau.

The unconformity which was described by Mr. McGee in the Sixteenth street cut, to which reference was made earlier, is not regarded by the author as pointing to a period of elevation and a subaerial erosion, but simply as indicating a change of current or possibly freshet conditions and therefore in no way differing from the unconformities in a cross-bedded deposit except in the size of the materials moved. Both the restricted area in which this unconformity is found, as well as its position at the head of the old delta near the mouth of the Potomac gorge where the current must have been constantly changing, point to this conclusion.

A comparison of the section proposed by the author with that formerly suggested by Mr. Darton is as follows:

Darton.	*Shattuck.*	
Later Columbia..........	Talbot formation.	Columbia Group.
	Wicomico "	
Earlier Columbia.......	Sunderland "	
Lafayette formation.....	Lafayette "	

After a careful study of the surficial deposits in Maryland an attempt was made to correlate them with the formations of New Jersey, belonging to the same period of deposition, as mapped and described by professor Salisbury.

An extended excursion was therefore made in New Jersey in the autumn of 1900, but satisfactory correlations were found impossible. The difficulty encountered did not arise from the lack of contemporaneous deposits but from the fundamentally different classification adopted by the New Jersey Survey. The author found that with the exception of the Lafayette, the terraces were all present and as strikingly developed in New Jersey as in Maryland, and that they were distinguishable not only in the region of Bridgeton but across the entire Coastal Plain to South Amboy. The Maryland classification then, if applied to Delaware and New Jersey, would still indicate Talbot, Wicomico and Sunderland, each developed in a distinct terrace and bearing the same mutual relations which they do further south.

The author was unable to detect any evidence of such a deformation as that described for the Pensauken, but on the contrary the levels at which the various terraces appear were found to agree very closely with those occurring in Maryland.

It was further observed that wide areas composed of reworked marl, falling within the Wicomico formation and building part of its conspicuous terrace, were left unmapped, except where they developed a gravelly phase, when this material was entered as Pensauken.

Whenever the Jamesburg formation was examined it was the belief of the author that the phenomena could be better explained by hypothecating changes in the force and direction of the shore currents than by an appeal to a sudden subsidence of the entire region of more than 200 feet near the close of the Pleistocene, and as sudden an elevation afterward. The author, from his study of the region from the Potomac to the Raritan, is convinced that the Jamesburg materials described are present in each of the Pleistocene formations and evidently represent special physical conditions, not an independent formation.

Without going into more details it is evident that the correlation which the author has employed in Maryland is fundamentally different from that employed by professor Salisbury in New Jersey. A comparison of the two systems of classification would give the following results:

COMPARATIVE TABLE OF MARYLAND AND NEW JERSEY PLEISTOCENE FORMATIONS.

Maryland Sections.	*New Jersey Sections.*
Talbot (lower portions of Later Columbia).	Parts of Cape May and Pensauken.
Wicomico (higher portions of Later Columbia).	Parts of Cape May, Pensauken and possibly Bridgeton.
Sunderland (Earlier Columbia).	Parts of Cape May, Pensauken and Bridgeton.

It is believed by the author that the methods of classification employed in Maryland are the natural ones, and that they will ultimately be found applicable to the determination of the marine Pleistocene deposits of much of the Atlantic Coastal Plain.

EDITORIAL COMMENT.

THE DEPARTMENT OF GEOLOGY IN THE NATIONAL MUSEUM.

Plates X-XIV.

It is proposed to give here a brief account of the Department of Geology in the U. S. National Museum, as condensed mainly from its published handbooks and annual reports. The purport of the paper is to show to what extent the department, as a national institution, is fulfilling its mission in caring for and rendering available to students the materials entrusted to its keeping, and further, in making an intelligent display for the benefit of the public.

The history of the U. S. National Museum may be said to date from the year 1846, when by act of Congress the custody of the National Cabinet of Curiosities, at that time deposited in the Patent Office building, was transferred to the Smithsonian Institution.

This act provided that "All objects of natural history, plants and geological and mineralogical specimens belonging or hereafter to belong to the United States, and which were then in the city of Washington, should be delivered to the Regents of the Smithsonian Institution, and together with new specimens obtained by exchange, donation, or otherwise, should be so arranged and classified as best to facilitate their examination and study." By a subsequent act it is decreed that "all collections of rocks, minerals, soils, fossils and objects of natural history, archaeology and ethnology, made by the Coast and Interior Survey, the Geological Survey, or other parties of the Government of the United States, when no longer ne[illegible] investigations in progress, shall be deposited in the National Museum."

The amount of geological material brought together under these acts prior to 1876 was, though valuable, comparatively small and extremely varied. It consisted mainly of the collection made by Prof. J. D. Dana and his associates during the Wilkes exploring expedition; by the various geologists accompanying the surveys for the Pacific railroads in 1854-5; the surveys west of the 100th meridian under the direction of the engineer corps of the army, and the U. S. Geological Surveys, under direction of Dr. F. V. Hayden. There were also various miscellaneous collections made by surveys under the direction of the general land office.

Prior to 1873 there were no paid assistants whose duty it was to look after the collections. Indeed, Prof. Henry's policy at that time was directly against the utilization of Smithsonian funds for museum purposes. Thus, in one of his reports, he writes that scientific service "can be obtained without charge" or paid "in proportion to the time of engagement."

The natural history collections, including the fossils, were, therefore, worked up by so-called collaborators, several of whom had offices, and some of them sleeping apartments in the Smithsonian building. Amongst the numerous collaborators mentioned are found such names as those of Conrad, Cope, Gabb, Leidy, Lesquereux, Meek and Newberry.

The completion in 1880 of the present museum building afforded an opportunity for expansion and incidental reorganization on a more practical basis. This found expression in the creation of numerous departments and the appointment of salaried officials to take charge of the various collections.

With the appointment of Dr. Geo. W. Hawes to the position of curator of geology and mineralogy, and Dr. C. A. White to that of curator of invertebrate fossils, began the history of the geological department of the museum as an independent department. Dr. Hawes' connection with the museum was, however, too short for his division to become fully organized.

and at the time of his death, which took place at Manitou, Colorado, in 1883, matters were in a state of great confusion, owing to the large amount of material that had accumulated and the extensive census work undertaken but necessarily uncompleted.

The rapid increase of the paleontological collections and the growing demand of the geological survey for space for storage and work-rooms, resulted in early additions to the honorary force, Mr. C. D. Walcott being appointed honorary assistant curator in charge of the paleozoic fossils in 1882, and Mr. L. F. Ward, honorary curator of fossil plants in 1883. In this same year Mr. L. W. Clark was appointed honorary curator of mineralogy.

In 1894 a partial reorganization of the division took place, resulting in placing the entire paleontological collections under the direction of Mr. Walcott, with Mr. Charles Schuchert as assistant curator; Prof. O. C. Marsh of Yale College having nominal charge of the fossil vertebrates.

From the time of the death of Dr. Hawes until 1897 the mineralogical and geological divisions, as a whole, remained without an official head, the assistants, Messrs. F. P. Dewey,* W. S. Yates and G. P. Merrill, retaining charge of their various divisions and reporting directly to the assistant secretary.

At this date a complete reorganization took effect which is still in force and is apparently working very satisfactorily. The entire department, including mineralogy as well as paleontology, is placed in charge of a head curator. In creating the various divisions and sections, regard has been had mainly to convenience in administration and arrangement of material most readily accessible for study and reference. The aim has been to give each officer control of such collections as he may be most interested in and not to hamper him with the care of a great amount of other matter. The general scope of the department in tabular form is given below:

DEPARTMENT OF GEOLOGY:
  George P. Merrill, Head Curator.
  (a) Division of Physical and Chemical Geology, (Systematic and Applied):
    George P. Merrill, Curator.
    W. H. Newhall, Aid.

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*Mr. Dewey resigned in 1889.

(b) Division of Mineralogy:
F. W. Clarke, Honorary Curator.
Wirt Tassin, Assistant Curator.
Dr. L. T. Chamberlain, Honorary Custodian of Gems and Precious Stones.
(c) Division of Stratigraphic Paleontology:
Charles D. Walcott, Honorary Curator.
Charles Schuchert, Assistant Curator.
(1) Section of Vertebrate Fossils:
F. A. Lucas, Acting Curator.
(2) Section of Invertebrate Fossils:
Paleozoic: Chas. Schuchert, Custodian; Geo. H. Girty, Custodian of Carboniferous Collections.
Mesozoic: T. W. Stanton, Custodian.
Cenozoic: W. H. Dall, Associate Curator.
Chas A. White, Honorary Associate in Paleontology.
(3) Section of Paleo-botany:
A. C. Peale, Aid in Charge of Collections.
Lester F. Ward, Associate Curator.
F. H. Knowlton, Custodian of Mesozoic Plants.
David White, Custodian of Paleozoic Plants.

Considered in the order above given, the following descriptive matter, compiled from the handbooks and annual reports of the various curators and assistant curators, will be found of interest.

Division of Physical and Chemical Geology, Systematic and Applied. In this division consideration is given to the bringing together, and so far as is practicable, preparing an exhibition of materials bearing upon the history of the earth in its cosmical aspect and illustrative of its composition and structure. Lack of space has prevented the carrying out of an ideal exhibition series, and from year to year it has become necessary to withdraw some of the smaller and less striking exhibits and install in their places materials of more general interest. It is not to be understood, however, that the exhibits that are withdrawn are rejected. They are simply placed in storage, where they may be available for reference, or for exhibition when space shall be provided.

The more important exhibits found here and which are of a nature, either on account of their size or rarity, as to seldom find their way into the smaller museums, are a cluster of basaltic columns in the position in which they were formed (see pl. XIV); a large series of specimens illustrating (1) limestone caverns and associated phenomena (see pl. XI); (2) glaciers and glaciation; (3) volcanoes and volcanic activity; (4) concretionary structures in crystalline and fragmental rocks (see pl. XII), and (5) faults, folds and other phenomena produced by purely dynamic agencies. In addition to these there is a systematic series of rocks and fossils from the various geological horizons of America.

Some of the more striking of the exhibits in this division are shown in the accompanying illustrations. The collections in this section now occupy a floor space of but 50 by 90 feet.

At the time Dr. Hawes entered upon his duties as curator, he also assumed charge of that branch of the tenth census relating to the quarry industry of the United States. To this work he gave almost his entire attention, and although his labors were unfortunately cut short when little more than a beginning had been made, yet the carrying out of the work as planned resulted in the accumulation of several thousand samples of building and ornamental stones, and the large mass of information relating thereto which appeared in volume X of the reports of the tenth census. Out of the materials thus collected upwards of 3,000 specimens were dressed in the form of four inch cubes for exhibition purposes. These have been described by the present head (then assistant) curator in a handbook of some 370 pages, published in connection with the annual report for 1886. Another important collection is a series of metallic ores and non-metallic minerals arranged on a geographic basis, i. e., by states, and a large series of economic materials arranged on one of the recently completed galleries in the southwest court, a section of which is shown in plate I. This last collection alone comprises upwards of 4,000 specimens, the non-metallic portion of which has been described in the report of the National Museum for 1899, just issued.

Space has also been devoted to collections illustrating the methods of treatment of ores, and reference should be made to an important series illustrating the extraction of gold, silver, lead, copper, zinc, iron and the manufacture of steel. This series, together with a descriptive catalogue of the systematic collections in economic geology, was described in Bulletin No. 42 of the National Museum, published in 1891. These series are very complete and illustrate all stages of the process from the crude ores to the finished product, with also the fuel, fluxes and various by-products. They are accompanied by engravings (plates from published handbooks) showing mines, mills and furnaces from which the various samples were taken. Each collection begins with a series of the ore-bearing minerals. This is followed by a series of the ores in which the ore mineral is evident to the eye, and this, in turn, by selected samples of the ores as mined, and in which, as is often the case, the ore-bearing mineral is wholly inconspicuous.

The economic collection is somewhat exceptional on account of the prominence given to what are classed as the non-metallic minerals (i. e., minerals not used as ores of metals). There are thus exhibited, grouped by usage and kinds, very complete series of natural pigments, abrasives, salts used in fertilizer and chemical manufacture, sulphur and sulphur ores, clays, limes and cements, diatomaceous earth and tripoli, asbestos, both crude and manufactured, mica, fluxes used in metallurgical operations, coals and other hydro-carbon compounds, etc. Some prominence is given to the rarer earths and minerals which are now coming into more general use, as monazite, cerite, zircon, spodumene and other lithia minerals, celestite, uranium compounds etc. These collections are described in detail in the handbook above mentioned, from which plate I of this article is taken. A feature which has thus far been largely overlooked in collections of this nature, is a consideration of water as a mineral and its exhibit among other economic mineral products. One case is given up to a display of this nature, selected to show kinds and geographic distribution in the United States.

Another collection which will bear special reference is that of crude petroleum. This comprises upwards of 300 samples, some of which are of historical interest, as a sample, in the original package, of the "medicinal oil" from Little Rennox creek, Kentucky, put up in 1856. The collection is arranged to show (1) variations in specific gravity and (2) color, (3) geological horizons, and (4) geographical distribution. A small series of distillation products is also shown, though here, as in other instances, the strictly technological side is from necessity, largely omitted. This collection is accompanied by maps showing the known distribution of petroleum and bituminous products throughout the world, and a small collection of oil sands and bitumen-bearing rocks.

These economic collections are the most systematic of their kind in the country, and in many respects the most complete and systematic of any public museum in the world.

By law, as noted above, the museum is the repository of all mineralogical and geological material collected by the various departments of the government, when the various investigations for which they were made are completed. This results in bringing together a vast amount of material, worthy of preservation, in fact, of the very greatest scientific value for reference and study purposes, but quite unsuited for exhibition. Materials of this nature are classified by kinds or by areas, according to the conditions under which they have been studied, and put away in drawers in storage cases, where they may be available whenever desired. Among the more important collections, which may be mentioned here, are those made by the early Hayden and Wheeler surveys; the tenth census iron ore series described by Pumpelly; the collections of the 40th parallel survey, including the lithological series described by Zirkel; the Washoe collections representing the work done by G. F. Becker and colleagues in the Washoe district and Comstock lode, Nevada, the results of which were published in Monograph 3 of the U. S. Geological Survey; the rocks of the Eureka district, as described by Hague and Iddings, in monograph 20, U. S. Geological Survey; the Pacific coast quicksilver collections, comprising several hundred specimens as described by G. F. Becker and colleagues in monograph 13 of the U. S. Geological Survey; the Leadville collection, comprising nearly four hundred eruptive, sedimentary and metamorphic rocks and ores collected and studied by Messrs. S. F. Emmons and Whitman Cross, and described in monograph 12 of the U. S. Geological Survey. It also includes type series of the rocks described by the survey petrographers—as those of the Silver Cliff and Ten Mile districts, Colorado—and representative series of rocks of the various published quadrangles.

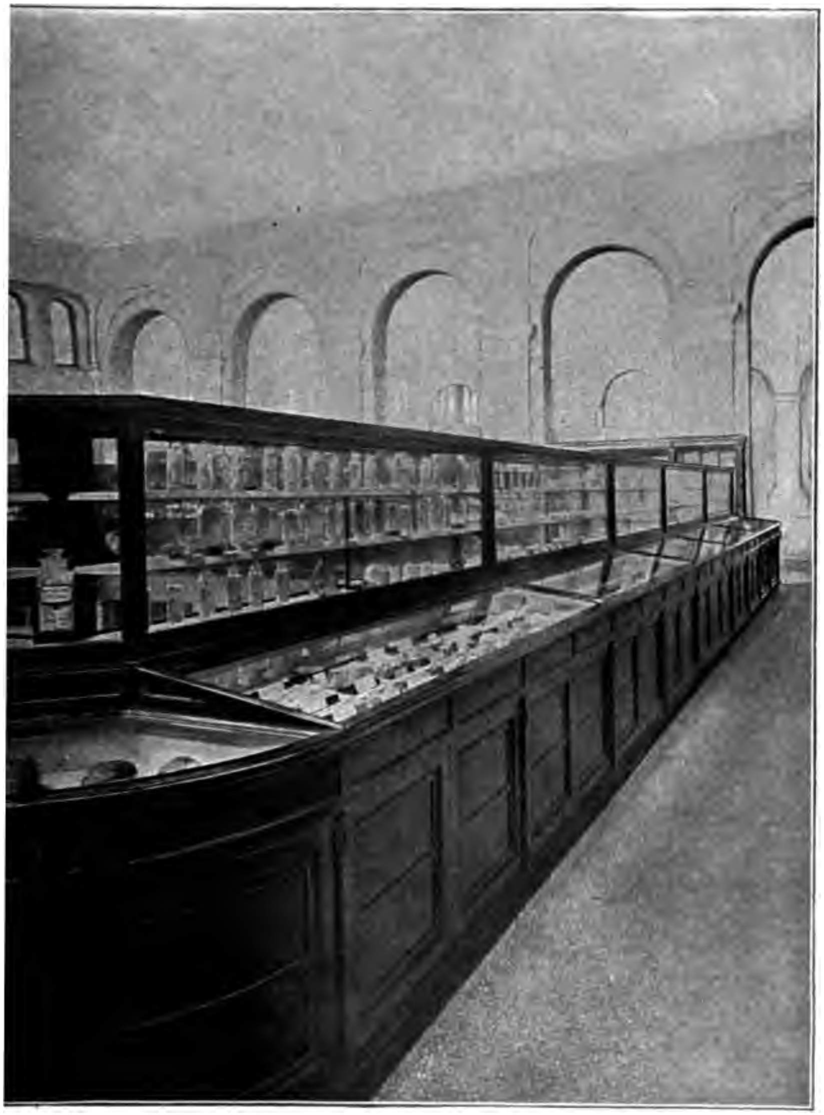
The mineral collection is evidently very systematic and contains much material worthy of special mention. Among the more noteworthy specimens is a fine large octahedron of gold and a cluster of crystallized gold showing nearly 20 more or less perfect octahedra. The collection also contains type specimens of warrenite, hanksite, spangolite, lawsonite, zunyite, and guitermanceite: also the complete series of uranium minerals used in investigations by Hillebrand which led to the discovery of nitrogen in uraninite and indirectly to the discovery of argon.

Among the more notable suites in the exhibition series may be mentioned a magnificent collection of Copper Queen azurites, Siberian topazes, and twinned calcites containing arborescent copper from the Lake Superior region. The collection is rich in specimens from the older Pennsylvania localities, as for example, a magnificent series of brucites mainly from the collections of Isaac Lea and Joseph Leidy; also a series of zaratites on chromite from the old Wood mine, Texas, Lancaster county, Pennsylvania.

Worthy of particular note here is a recent accession from Dr. C. U. Shepard of Summerville, South Carolina, comprising the entire private collection of the late Prof. Chas. U. Shepard. This is especially valuable, since it contains Dr. Shepard's type materials and specimens, from which drawings were made for purpose of illustration in the earlier works on mineralogy. It also contains fine examples from localities now inaccessible or exhausted.

The large block of native copper described by Schoolcraft in his narrative of explorations of the source of the Mississippi in 1820, from Ontonagon county, Michigan, is displayed in this section of the department.

A comparative series, designed primarily for students of mineralogy, and which illustrates various characteristics or properties of minerals, containing some 2,800 specimens, is arranged along the west side of the hall. The gem collection, which since the recent generous accessions to the collections in the American Museum in New York, now ranks as second of the public collections in the country, owes its origin to an exhibit of precious stones made by the National Museum at the Cincinnati and New Orleans expositions in 1884 and 1885. In 1894 the museum secured by purchase the Leidy collections of gems and later, by request, the important collection of Dr. Isaac Lea. Since that time the growth has been rapid and systematic, owing largely to the influence of the honorary custodian, Dr. L. T. Chamberlain. Particular effort is made to illustrate the gem resources of the United States. A large, rich green,



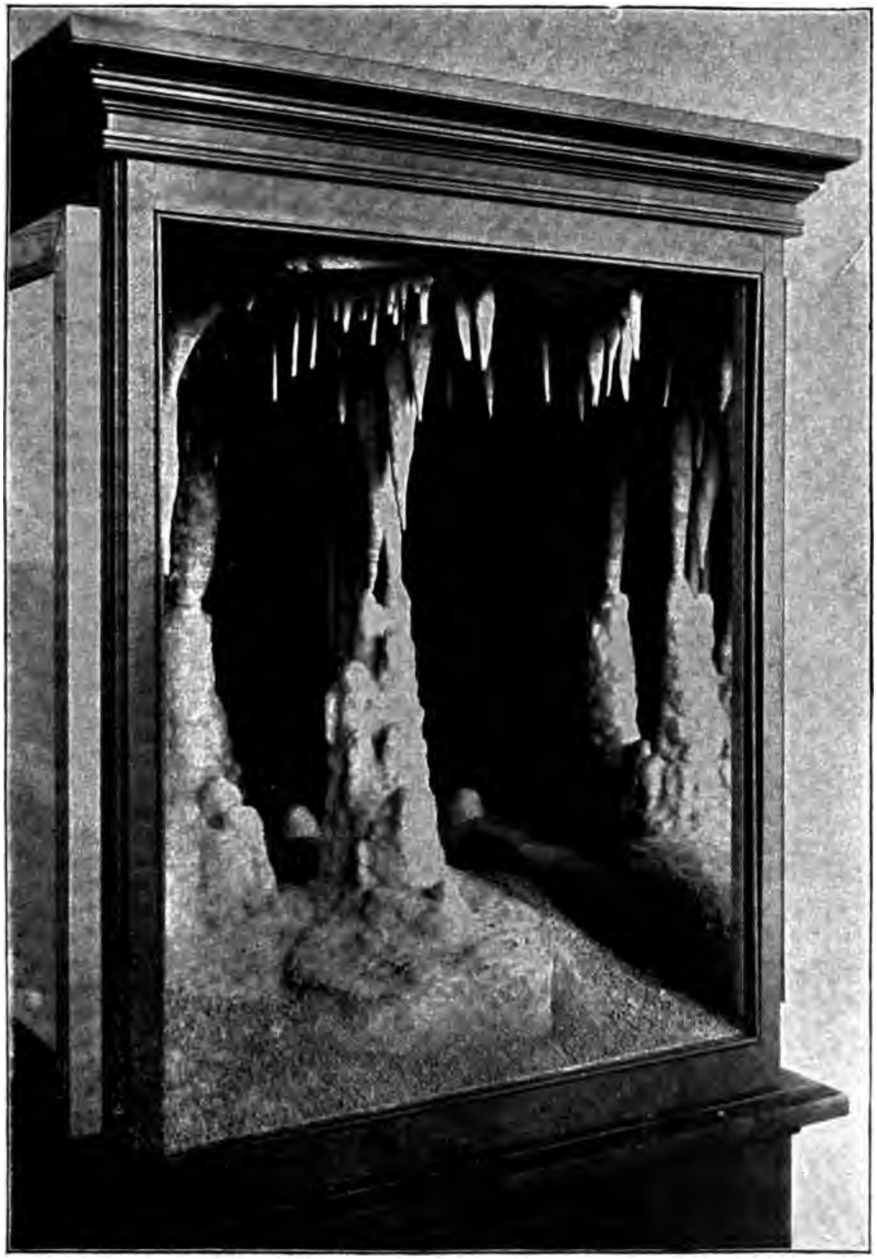
SHOWING INSTALLATION OF ECONOMIC MATERIALS, IN GALLERY IN NATIONAL MUSEUM.

(*From Ann. Rep. U. S. Nat. Museum for 1899.*)

THE NEW YORK
PUBLIC LIBRARY.
ASTOR, LENOX AND
TILDEN FOUNDATIONS.

THE NEW YORK
PUBLIC LIBRARY.

ASTOR, LENOX AND
TILDEN FOUNDATIONS.



SECTION FROM MARENGO CAVE, INDIANA, AS INSTALLED IN THE NATIONAL MUSEUM.

(*From Report of U. S. Nat. Museum for 1893.*)

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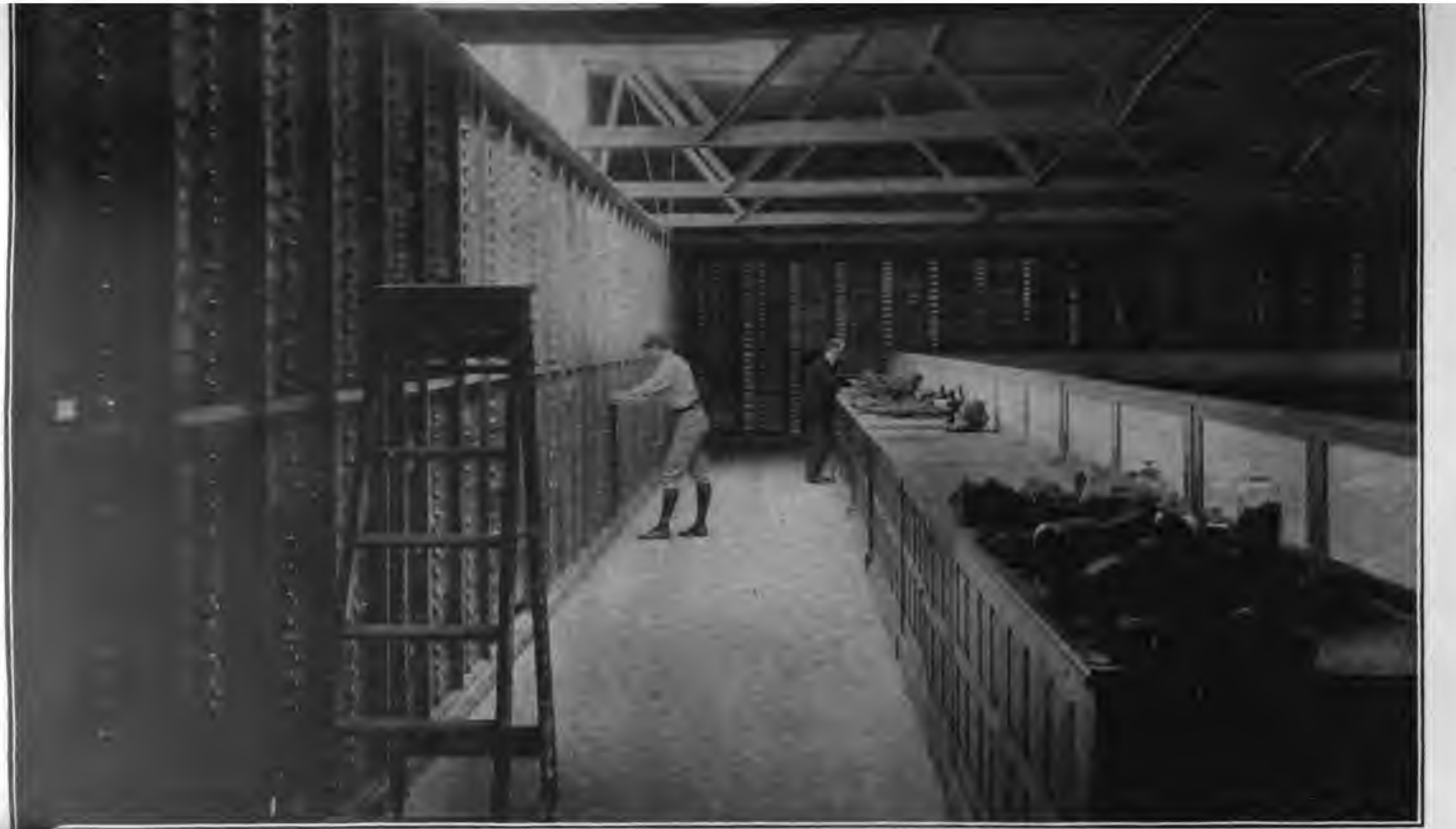

VIEW SHOWING STORAGE CASES FOR PALEOBOTANICAL COLLECTIONS.

[illegible] YORK
[illegible] LIBRARY.
[illegible] AND
TILDEN FOUNDATIONS.

brilliant cut tourmaline, weighing 57½ carats, from Paris, Maine, is noteworthy. There is also a fine, claret-red tourmaline, weighing 17½ carats, from the same locality.

There are also sapphires and rubies from the Jenks' mine, Macon county, North Carolina, including the dark-brown, asteriated form described by Kunz in the transactions of the New York Academy of Sciences in 1883. The recently discovered Montana sapphire locality is represented by a beautiful suite of specimens, characteristic for their remarkable lustre and marked dichroism.

The beryl series comprises what is supposed to be the largest emerald crystal found in North America, and a fine series of cut emeralds and beryls from North Carolina, as well as a fifteen-carat, cut stone from the quarries at Portland, Connecticut. This last is of a rich, deep aquamarine color, fairly rivaling the best Brazilian stones.

The collection also contains a fairly satisfactory series of cut hiddenites from Alexander county, North Carolina; a cinnamon-colored, fifteen-carat, cut topaz from Pike's peak, Colorado, and a selected series of cut turquoises from New Mexico, the gift of the American Turquoise Mining Co.

The meteorite collection comprises, all told, some 752 specimens representing 329 distinct falls or finds. The more notable specimens in this collection are the historical Tucson or ring meteoric iron, the Allegan stony meteorite which fell in Michigan in July, 1899, and the unique Bishopville stone, discovered in 1843. A special effort is made to secure representatives of all American falls and but little attention is paid to minute fragments too small for study.

Section of Invertebrate Fossils. The paleontological collection, like other of the collections in the geological department, consisted at first very largely of material brought in by the government exploring expeditions. Incidentally many small lots were presented or received in exchange and a few purchased. Other additions have since been made through the governmental exhibits in which this section has taken part. A valuable collection of fossil insects and a few vertebrates formed a part of the Lacoe collection mentioned elsewhere. Perhaps the most important collection of invertebrates that has come to the section by bequest is what is known as the I. H. Harris collection of Lower Silurian invertebrates from southern Ohio. This contains over 20,000 specimens and is referred to in the report for 1898 as one of the finest ever made from the rocks of the Cincinnati group, being particularly rich in starfishes, crinoids, and trilobites, including numerous type specimens.

During the past 20 years the section has naturally been very greatly enriched by materials turned over by the U. S. Geological Survey. How rapid has been the growth of these collections is shown by the record books, which, in 1859, had less than one thousand entries; while, in 1898 alone, more than 33,000 specimens were added and the total accumulation is estimated at some 350,000 specimens, very many of which are, of course, duplicates.

No inconsiderable part of the value of these collections lies in their type specimens, or those which have been illustrated in the various works on paleontology. It is stated that there are, all told, something like 4,575 lots which have been thus described and figured.

The exhibition space for this section is limited to 300 running feet of space on one of the galleries. The exhibits are divided into (1) a historical collection, (2) a synoptic collection, and several minor series illustrating development of the faunas of particular areas. The great bulk of the invertebrate collections are, however, stored in drawers constituting what is known as the reserve series. The paleozoic collection is very rich in Cambrian and Ordovician types, a condition due largely to the efforts of Mr. Walcott and the I. H. Harris bequest. The Devonian and Carboniferous faunas are, however, only fairly well represented and the Silurian series is reported as being comparatively weak. The entire paleozoic series, aside from that portion on exhibition, is now stored in something like 1,300 drawers. The mesozoic collection is rich in materials from the southern and western states, but weak in specimens from the Atlantic border. The Tertiary collection is exceedingly rich.

Section of Vertebrate Paleontology.—Prior to 1898 this section, though containing many of the types of Cope, Leidy and Newberry, made very little display, the specimens collected by the earlier geologists and explorers being almost invariably of a fragmentary nature.

In 1898 Prof. O. C. Marsh, then acting as an honorary curator of vertebrate fossils, transferred a portion of the collection made by him under the auspices of the U. S. Geological Survey, to the museum, and the history of the section might well begin with this date. After the death of Prof. Marsh the entire collection belonging to the government was transferred to the museum, as has been noted in a prevous number of this journal.* As is there stated, the actual number of specimens represented in the collection cannot be stated, since they range from minute teeth of fossil mammals to individual specimens weighing from 500 to 2,000 pounds each. The collections are rich in Dinosauria, especially in Triceratops and Stegosaurus, while the series of Titanotherium skulls is probably the best in existence, containing more than fifty complete examples already cleaned and a number in the rough.

Among the specimens thus transferred are the types of forty or more species, including dinosaurs and Jurassic, Cretaceous and Tertiary mammals, the more important of which are as follows:

DINOSAURS.

Labrosaurus ferox,
Camptosaurus nanus,
Triceratops calicornis,
Triceratops Obtusus,
Triceratops elatus,
Ceratops montanus,
Ceratops alticornis,
Pleurocoelus nanus,
Stegosaurus stenops,
Stegosaurus sulcatus,

CROCIDILES.

Rhytidon rostratus.

SNAKES.

Coniophis precedens.

JURASSIC MAMMALS.

Paurodon valens,
Menacodon rarus,
Ennacdon affinis,
Ennacdon crassus,
Laodon venustus.

CRETACEOUS MAMMALS.

Priconodon crassus,
Crimolodon agilis,
Telacodon præstans,
Oracodon cenulus,
Allacodon fortis,
Batodon tenuis.

TERTIARY MAMMALS.

Titanotherium dispar,
Trigonias obsorni.

The work of cleaning and mounting vertebrate fossils is slow and expensive and it will be many years before the museum, at the present rates, can exhibit a series of these interesting remains which will be at all satisfactory. A beginning has, however, been made.

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* AMERICAN GEOLOGIST, March, 1900, pp. 171-173.

The department has for many years been the depository of miscellaneous collections of fossil plants made by various exploring expeditions and geological surveys, but it was not until 1892 that the paleobotanical series became of sufficient importance to merit consideration among the great collections of the world. In this year, the late Mr. R. D. Lacoe gave to the government his entire collection of fossil plants, a collection the value of which has been partially made known to the scientific world through Lesquereux's Coal Flora, of the second geological survey of Pennsylvania. This collection is estimated to contain, all told, not less than 100,000 specimens, of which 575 are original types.

In addition, there are the collections described in Lesquereux's Cretaceous and Tertiary Flora, vol. VIII. of the report of the Hayden Survey, and his Flora of the Dakota group, monograph 17 of the present U. S. Geological Survey, and in Fontaine's Mesozoic Flora of North America, monographs 6 and 15, U. S. Geological Survey; Newberry's Later Extinct Flora of North America, monograph 35, U. S. Geological Survey; White's Fossil Flora of the Lower Coal Measures, monograph 37, U. S. Geological Survey, and others of less importance. It is easy to see, therefore, that the collection is by far the largest and most valuable of its kind in America, and perhaps in the world. It contains altogether not less than 2,000 types and figured specimens.

The view here given (plate XIII) from the annual report of the Museum for 1900, shows the gallery of the Museum devoted to the storage of the study series of fossil plants. The section has here some 1,900 drawers, giving an area of 10,000 square feet of storage space. The table cases around the outer edge of the gallery serve as convenient tables for the laying out of material for study.

The question as to what extent it is proposed to carry the exhibition series in the Museum is an important one. The present feeling on the part of the officers of the various departments, is that a practical limit is very quickly reached. A comparatively small number of well-selected, well-preserved, typical forms, properly labeled and so installed as to attract attention and at the same time convey an idea, are recognized as of greater value than dozens of specimens of poorer materials displayed in a less satisfactory manner. In fact, unless each succeeding specimen illustrates some new feature, the smaller the display the better. But, how to so display a specimen as to get the maximum value, is a question with which the curators of every museum are still struggling. Color of case interiors, direction of light, character of label and many minor points have to be considered. In the department of geology the prevailing color for case interiors is a warm cream tint. Years of experience have shown this to give most general satisfaction, when its non-fading character and the varying color of the specimens are taken into consideration. Labels are brief and printed with heavy-faced black type on gray green board. This color is not all that might be desired from a purely æsthetic standpoint, but it has been selected as affording a label that is legible and non-fading; the first essentials of a label are considered legibility and conciseness of statement. In the early history of the department, labels were much larger than at present. It was found, however, that not merely would it prove to be a practical impossibility to label the entire collection as fully as proposed, but that the public did not demand such. Certain striking specimens of large size, or of peculiar interest for other reasons, do demand full explanatory labels. In the systematic series it has, however, been found that a brief label, giving name and locality, best serves the purpose, additional information being given in the case label and in books of reference placed upon the tables in the halls. As a rule, no specimen such as cannot be replaced is put upon exhibition, if more liable to injury or deterioration there than in the drawers of the reserve series. Nor is a specimen necessarily considered as withdrawn from the study series by being placed upon exhibition.

The question of getting a maximum number of specimens into a case, with a minimum amount of interference or shadow, has been quite satisfactorily solved, so far as the section of vertebrate fossils is concerned, by the means shown in plate V. As will be noted, shelving is done away with, excepting that afforded by the bottom of the case and two narrow shelves at the top, for large and heavy materials which are often out of classification as compared with the rest of the exhibit. The fossils are here cemented to encaustic tiles of standard

they individually are absorbed, are disposed to neglect the claims of the educated public to the enjoyment and instruction which museums afford. They do not hesitate to say that scientific museums should be administered for the benefit solely of persons engaged in research. Such men would find no welcome among us."

The privilege above noted has been appreciated, as is shown by the large number of packages received daily with requests for identification. "Since the museum was opened in 1881, not less than 6,000 persons have taken advantage of this privilege, and not a day passes without receiving similar requests." As may readily be imagined, very many requests for assays and analyses of material of supposed economic value are received. The museum has, however, no facilities for this work.

The National Museum is not organized primarily as a bureau of research, but rather as a museum of record, a place for the preservation of the types of past investigations. The first duty of its officials relates, then, to the care of the collections. The amount of original work that is put out from year to year may not, therefore, be as great or, possibly, in all cases of as high grade as would be the case under more favorable circumstances. That a large amount of good work is nevertheless, being done, is self-evident.

Materials donated to the museum or deposited for preservation must, of course, be retained indefinitely, unless an agreement is made to the contrary. Nevertheless, by one means or another often through the direct personal efforts of the curators a large amount of duplicate material is acquired, which, as occasion offers, is made up into sets and distributed under congressional endorsement to schools and colleges, or sent out by way of exchange. It is calculated that, from the department of geology alone, there have been thus sent out during the past ten years not less than 30,000 specimens of rocks, ores, minerals and fossils.

The seriously crowded condition of the museum exhibition halls is a subject of chronic complaint in all of the reports. Confining our attention to the geological department, it is evident that the present exhibits would be much more attractive could they be made to occupy at least one-third more space. The aisles between the cases are too narrow: the light is thereby diminished, and the general view obstructed. The collections in invertebrate paleontology occupy only about one-half the space at present desired, and the space devoted to vertebrate remains will prove ridiculously insufficient so soon as the work now under way of restoring some of the larger remains of Triceratops, Stegosaurus etc., is completed.

The workrooms of the department are at present in a rented building, several blocks from the museum, while hundreds of boxes of materials from the various surveys are stored in the sheds, where not readily accessible. Laboratories and offices are too crowded to admit of satisfactory accommodations for more than the present force. The entire space at present devoted to exhibition and study installation amounts to a little short of 25,000 feet. It is estimated that at the present rate of growth 100,000 square feet will be none too much to supply all the needs of the department during the next ten years.

G. P. M.

REVIEW OF RECENT GEOLOGICAL LITERATURE.

Die Ursachen der Oberflächengestaltung des Norddeutschen Flachlandes. von DR. FELIX WAHNSCHAFFE. 9 plates and 33 text-illustrations. pp. 258. Second edition, fully revised. Stuttgart. J. Engelhorn. 1901. 10 marks.

Since the initital examination and publication by Salisbury and Wahnschaffe on the moraines bordering the southern Baltic in Germany, the glacial geology of Germany has received much more attention than ever before, and especially by Dr. Wahnschaffe. In this volume (which would be much improved by the addition of an index) the author has gathered all the essential facts known relating to this interesting region, whether observed by himself or by others, making a monograph similar to those of Upham and of Leverett on certain portions of the drift of the United States, but less bulky. He describes, and frequently illustrates by diagrams, the various elements of the drift-plains, including their terminal moraines, and concludes with a chapter on post-glacial modifications of the drift, whether by wind or by wave. In giving the order of succession of the north German Quaternary formations, as indicated by the facts presented in the volume, the author presents the following scheme:

POST-GLACIAL.

(a) *Later:* Beech and alder (with Mya).
(b) *Earlier:* Oak (Litorina); Birch, Pine (Ancylus).

GLACIAL.

Latest glacial phase; Dryas (Yoldia); Fauna and flora still sub-arctic.

Third ice age; (a) Melting period; terminal moraines, sands of valleys and terraces, osars, kames, gravel, loess. (b.) Covering of land ice; Upper marl sand (ground moraines), subglacial sand and gravel.

Second interglacial epoch: Fauna of large animals; interglacial peats; deposits containing fresh-water shells; marine formations containing certain oyster beds, clays, with Cypris and diatoms.

Second ice age: Lower marl sand (ground moraines), fluvio-glacial gravelly, sandy and clayey deposits.

First interglacial epoch: Fresh water deposits, peat and calcareous tufa, sands with Valvata. Marine deposits, sands with Cardium, Yoldia and Cypris. Diatoms.

First ice age: Ground moraines and older fluvio-glacial sediments.

Pre-glacial time: Deposits not yet demonstrated, although some of the fossiliferous beds above assigned to the first interglacial epoch have been considered pre-glacial. N. H. W.

Le granite des Pyrénées, et ses phénomènes de contact. 3 plates, 16 text figures. pp. 68. By A. LACROIX. Ch. Beranger, Paris, 1900. (*Bull. Ser. Carte Geol. France* No. 71.)

The facts and conclusions therefrom given in this bulletin are very important, considered from a petrological point of view. This publication marks perhaps an important epoch in European geological literature. While some of the conclusions have been, here and there, anticipated by earlier publications, in no case have they been so fairly presented, nor so fully supported by reference to field evidence. The author is one of the most skilled and, at the same time, one of the most cautious of living petrographers and he has spent several years in gathering and in studying the field facts, and in the necessary laboratory work. His results necessarily carry conviction to all who are open to conviction. It will be difficult to question them with good reason adversely until the same facts shall have received equally as long and detailed a study. These important results can be summarily stated as follows:

1. The granite of the massif of Querigut-Millas surrounds and incloses along the south side a large band of paleozoic limestone. On the southern border this limestone band is separated from some schists by the enclosing spur of granite.

2. Along the southern side of the granitic massif exomorphism is notable, in the schists and in the limestone, the former taking the character of leptynolytes, or feldspathic mica schists, with frequent development of tourmaline, andalusite, cordierite etc., also sillimanite and microcline. A special type contains abundant orthoclase and oligo-

clase, with biotite and graphite, and still another ilmenite, allanite and epidote. The limestone is mar-morized and garnetized with reddish yellow grossulaire in large rhombododecahedrons. In other places it is rich with epidote and hairy idocrase, with wollastonite, diopside, chabazite and stilbite. In these modifications sometimes microcline and sometimes quartz is in the last mineral formed. Epidote increases to form epidolyte. It is then granulitic and pyroxenic. Sometimes it is rich in sphene, diopside and blue tourmaline. The limestones also take the form of compact dense feldspathic rocks derived from thin alternating beds of limestone and of schist, constituting a banded hornstone. Talc appears also as a product of such modifications, and beds of magnetite as a pneumatolitic product at the contact planes. In the marble are also veins of aplyte and pegmatyte. These veins are not derived from injection from the granitic magma, but from slow molecular filling of fissures by the action of mineralizing waters.

3. Along the northern slopes of the granitic massif the exomorphism is less, and the granite is much decayed and granulated. It contacts on Silurian schists and Premo-Carboniferous and Devonian limestones and on Secondary limestones. The modified sedimentaries present essentially the same characters as on the south side.

4. The granite passes progressively to hornblende granite, then to quartz dioryte, to basic dioryte and to hornblendytes, including noryte and hornblendic peridotyte.

5. These several rocks are separated, in different stages of alterations, from the normal granite, by a form of granite containing inclusions showing different degrees of exomorphism.

6. There is a clear, close connection between the nature of the sedimentaries adjacent and these inclusions, indicating their source.

7. It is logical, therefore, to consider these inclusions sometimes as fragments from the sedimentaries highly exomorphosed or sometimes as portions of the granitic magma endomorphosed by the digestion of such fragments. Yet they approach so closely together in mineral nature that sometimes their source whether in the magma or in the sedimentaries cannot be distinguished.

8. The granitic magma could have absorbed a great quantity of the schists without having its mean composition much altered.

9. The absorption of calcareous sediments produces intermediate phases of basicity in the granitic magma.

These conclusions bear directly on the theoretical origin of the basic and intermediate eruptive rocks, and seem to render the notion of magmatic differentiation unnecessary, and at this place inapplicable. At the same time it should be noted that Prof. Lacroix does not permit himself to *universalize* these results, but states that every case must be studied by itself. N. H. W.

Geologischer Fuhrer durch Campanien. Von Dr. W. Deecke.

This is No. 8 of the collection of geological guides published by Gebrüder Borntraeger, Berlin, 1901. Costs 4 marks. This guide would be particularly valuable to tourists interested in volcanic phenomena. It has, besides general maps, special maps of volcanoes and photographic views of some of their scenery; also a bibliography of the chief literature. N. H. W.

The Coal and Metal Miner's Pocketbook of Principles, Rules, Formulas and Tables. THE COLLIERY ENGINEER COMPANY, Scranton, Pa. Sixth edition, revised and enlarged with original matter. 1900.

This handy and gilt-edged little volume is fully described by its title. It is printed on fine, calendered paper in solid nonpareil type, and contains in small space a vast amount of technical information. It contains a glossary in which are definitions of many Mexican and Cornish terms. This glossary, however, is almost destitute of geological and mineralogical terms. It is apparent that no geologist had part in its compilation. "Archean" is defined as "an early period of geological time." Any geologist would have said *the earliest period of geological time.* The presence, moreover, of such a definition as this: "*Argol*—A crude tartar deposited from wine," is almost a demonstration that some expert other than the geologist selected the terms of this glossary, for no geologist would assume that such crude tartar has any relation to coal or metal mining. N. H. W.

Report on the Geology of the Philippine Islands. GEORGE F. BECKER. (From the 21st Annual Report of the United States Geological Survey. Washington, 1901.)

Mr. Becker has admirably begun the Governmert's geological work in the Philippines. He has catalogued all earlier geological publications, of whatever nationality, and his deduced from them a compact sketch of what is known of the geological structure and history of the entire group of islands. At the same time he has added his own observations, and has given to the whole interesting sketch a decidedly original and American clearness, as well as completeness.

In the eastern part of Luzon, and of other islands, are crystalline schists and massive rocks, gneiss, granite in small quantity, possibly some syenyte, while diorytes, diabases and gabbros are abundant. Similar formations are found in the eastern portion of other islands. Some of these rocks may be Archean, by analogy with the geology of Borneo and of Java, but the diabases and gabbros are thought to be mainly post-Carboniferous.

Of stratified rock, Dr. Becker states that none are known of pre-Tertiary age—although they may exist, and do exist in adjacent island groups to which the Philippines seem to be allied in one geological province. The Eocene is supposed to exist, but it is not well authenticated. Certain black lignites have been reasonably supposed to be of the Eocene, and that would require the Eocene through the southern provinces of Luzon, and in the Visayas. The Miocene seems to have a basal conglomerate, indicating non-conformity on the Eocene Other strata are considered Pliocene and post-Pliocene. The islands have received a recent uplift, after peneplanation, thus forming extensive plains that are fertile, and thickly settled. This uplift began in the later Miocene and still continues, being marked by successive terraces and by elevated coral limestones.

The author thus summarizes the probable geological history of the Philippines:

"Summarizing the foregoing facts and inferences, it would seem that the geological history of the Philippines is something as follows: From early Paleozoic times onward an archipelago has usually marked the positions of these islands. Prior to the Eocene nothing definite is known of them, but further investigation will very likely disclose Paleozoic and Mesozoic strata there as in the Sunda and the Banda islands. During the Eocene it is probable that the lignitic series of Cebú was deposited, and the contorted indurated strata, which in other localities also carry black lignite relatively free from water, should be referred provisionally to this period. Whether the nummulitic limestone found at Binangonan is Eocene seems to me to be an unsolved question. After the Cebúan lignitic epoch a great uplift and folding took place, and this may have been a detail of the late Eocene movement which so profoundly modified Asia and Europe. It must have brought about temporary continuity of land area between Borneo and Luzon. Somewhere about the middle of the Miocene the country sank to a low level. Many of the present islands must then have been far below water, while Luzon and Mindanao were represented by groups of islets. Observations appear to suggest that the Agno beds represent the basal conglomerate formed at this subsidence. A slow rise began again during the later Miocene, and may have continued to the present day without inversion, yet the actual distribution of living forms is such as to give some grounds for believing that, at some intermediate period, the islands were a little higher than they now are, but sank again only to rise afresh. The diorytes and associated massive rocks, including their tuffs, may have made their appearance about the close of the Paleozoic. The less siliceous of these rocks seem to have followed the more siliceous intrusions as a whole. The gold deposits, and perhaps other ores, are so associated with these massive rocks as to indicate a genetic relation. The neo-volcanic period began as early as the highest Miocene horizon, and very probably at the post-Eocene upheaval. If the semi-plastic marls of Cebú are all Miocene, the earlier andesitic rocks, at least, date back nearly to the great up-heaval. Among these rocks, also, there is sometimes a tendency for the basalts to follow the andesites, but the one dacite found at Corregidor is later than the andesites of that island. The relation of the trachytes to the andesites is not certain, but the sanidine rock is probably the earlier. A very large part of the neo-volcanic ejecta has fallen into water and been re-arranged as tuffaceous plains. The volcanic vents appear to me to occur rather on a net work of fissures than on a single system of parallel diaclases, and the volcanic activity is to be regarded as a thermal manifestation of the energy of upheaval." N. H. W.

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Geology of the Shonkin sag and palisade butte loccoliths in the Highwood mountains of Montana. (Am. Jour. Sci., vol. 12, pp. 1-17. July, 1901.)

White, David

The Canadian species of the genus Whittleseya and their systematic relations. (Ott. Nat., vol. 15. July, 1901. pp. 98-110, pl. 7.)

Willmott, A. B.

Michipicoten Huronian area. (Am. Geol., vol., 28, pp., 14-19, pl. 8. July, 1901.)

CORRESPONDENCE.

Recent Submergence of the Asiatic Continent. As I have not yet had time to present in detail the facts which led me to become convinced of the recent extensive subsidence of the Asiatic continent, I may be permitted in advance to mention two points which will help to clear up the doubts expressed by Prof. Claypole in his communication to the July number of the American Geologist.

The first point relates to the origin of the loess in northern China. Prof. Geikie, on page 699 of the revised and enlarged edition of his "Great Ice Age," in 1895, gives expression to the same opinion that is entertained by Prof. Claypole, that the material of the loess is "largely of fluvio-glacial origin,' while on a previous page (697) he accepts without reservation, the statement of Przevalski that "undoubted traces of former glaciation are seen in the Suma-Hada range, west of Kalgan in China." In his map facing page 691 Geikie also represents this region west of Kalgan as containing an extensive glaciated area.

Believing at the outset, as I did, in the glacial origin of loess material and in the probable correctness of Przevalski's inference, I took a 450-mile ride on muleback into the Mongolian frontier to verify the theory. This enabled me both to see the most significant deposits of loess in China and to cross and recross the mountains on the border of the Mongolian plateau where the glaciers must be located to furnish the loess material for that region, if indeed it were of glacial origin. But though traversing this most probable glaciated area for a distance of 150 miles, we found not only no evidence of any former glacial occupation, but abundant evidence that there had been no glaciation of the region. The whole erosion of the region has been sub-aerial, rather than subglacial.

If our conclusions be correct (and they accord with those of Richthofen) the glacial origin of the loess of northeastern China must be abandoned; and if abandoned there, I see not why it should, except on special evidence, be maintained with reference to other localities. Furthermore, though our examination of the facts along the base of the Ala-Tau mountains in Turkestan was not so complete as that in eastern Mongolia, it was such as to leave little doubt in our minds that the glacial phenomena of those mountains were entirely incompetent to account for either the amount or the distribution of the loess over which we traveled for many hundred miles.

A second point which was made in my paper published in the *Quarterly Journal* of the London Geological Society (vol. [illegible], p. 249) relates to the extensive deposit of beach gravel upon the face of the precipitous cliff of volcanic rock which rises immediately back of Trebizond on the Black sea. This deposit reaches to a height of [illegible] feet above the sea, and is of a character and extent such as [illegible] precludes its accumulation in any other way than by wave action at that level. The material is not local, it is much rounded, it has no possible relations to any local streams which might have deposited it, it is fresh in appearance, and is subsequent to all the principal [illegible] erosion of the region. In presence of these facts, our failure to find seashells, or indeed the total absence of seashells, would not weigh strongly in the balance against the inference that they indicate a recent water level of the Black sea.

Since returning home one of my pupils, who is skilled in such investigations, informs me that he has found a similar deposit near Samsoun, which is also upon the Black sea about one hundred miles to the west. But I will not anticipate the full statement of the facts which I hope to make when the present pressure of my daily duties shall be removed.

G. FREDERICK WRIGHT

Oberlin, July 22, 1901.

BILLINGS AND HIS BIBLIOGRAPHY: Will you please add the following titles to the bibliography of Elkanah Billings, given in the May number of the AMERICAN GEOLOGIST? I am indebted to major A. W. Vogdes of Brooklyn, for four of these references.

1860.

Additional Note on the Potsdam Fossils Amer. Jour. Sci & Arts. Vol. 30, 1860, 2d Ser., pp. 337-338; New Haven, Conn.

1862.

On professor Hall's Claim of Priority in Determination of the Age of the Red Sandstone of Vermont. Amer. Jour. Sci. & Arts. 2d Ser., Vol. 33, pp. 370-376, 1862; New Haven, Conn.

1865.

Notice of Some New Genera and Species of Palaeozoic Fossils. Can. Nat. & Geol., Vol. 2, 2d Ser., pp. 425-432, Dec., 1865; Montreal, Canada.

1869.

Note on the Structure of the Blaistodea. Amer. Jour. Sci. & Arts. Vol. 47, p. 353, 1869; New Haven, Conn.

1872.

On Some New Species of Paleozoic Fossils. Amer. Jour. Sci. & Arts, Vol. 3, 3d Ser., pp. 352-360; New Haven, Conn.

Ottawa, Can. H. M. AMI.

PERSONAL AND SCIENTIFIC NEWS.

PROFESSOR W. M. DAVIS is in the west, on a second geological trip to the Grand Cañon.

PROF. H. F. OSBORN spent part of June inspecting the work of his exploring parties in Wyoming.

MR. S. F. EMMONS will make a supplementary report on the Leadville mining district of Colorado.

DR. C. P. BERKEY, of Minneapolis, made a professional visit, in July, to mining points in Montana.

DR. W. D. MATTHEW, of the Am. Mus. Nat. Hist., is in eastern Colorado hunting for fossil vertebrates.

AT JOHNS HOPKINS UNIVERSITY Dr. H. F. Reid has been promoted to the professsorship of geological physics.

DR. U. S. GRANT, of Evanston, was enegaged recently in the investigation of certain graphite deposits in Georgia.

DR. JOS. LE CONTE, professor of geology and natural history at the University of California, died June 6, aged 88 years.

MR. GEO. H. ELDREDGE will examine and report on the oil regions of California for the United States Geological Survey.

MR. J. B. WOODWORTH is continuing, for the New York survey, his study of the problems of submergence in the state.

THE ONTARIO BUREAU OF MINES has a fine exhibit of the minerals and ores of the Province at the Pan-American Exposition.

DR. E. O. HOVEY, of the Am. Mus. Nat. Hist., is spending several weeks in the Black Hills region collecting Jurassic invertebrates.

A PROFESSORSHIP OF GEOLOGY has been established at the University of Colorado, the first appointment being Doctor N. M. Fenniman.

MR. J. S. DILLER, of the United States Geological Survey, will examine the geology of the mining district at Bully Hill, Shasta county, California.

PROFESSOR W. G. TIGHT, of Denison University, has resigned, to become president and professor of geology in the University of New Mexico.

THE HONORABLE C. D. WALCOTT was recently given an honorary LL. D. at Chicago University, and Mr. Arnold Hague a D. Sc., at Columbia University.

MR. G. D. HUBBARD, recently a graduate student at Harvard University, has been appointed instructor in geography at the State Normal School, Charleston, Illinois.

DR. GILBERT VAN INGEN has severed his connection with Columbia University and, during the present season, is engaged in field work on the lower paleozoic formations about the Adirondack mountains for the New York geological survey.

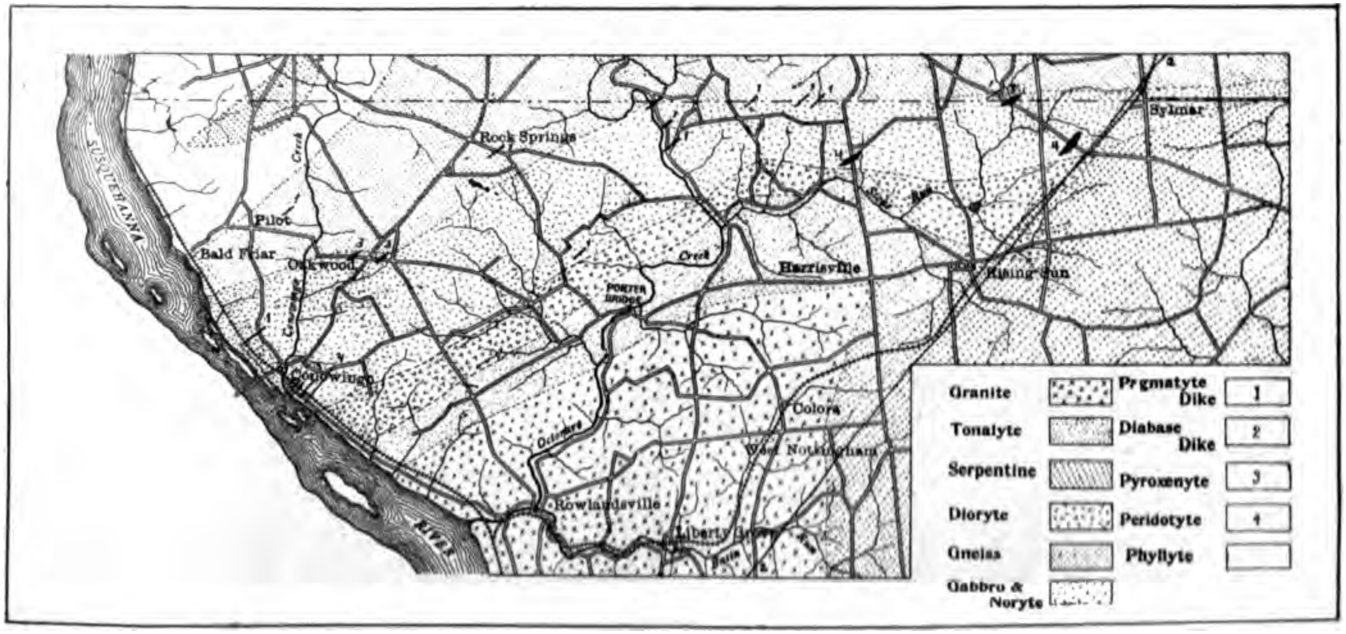
In western Wyoming oil was accidentally discovered by the operators in the construction of a railroad. It naturally flowed about five barrels per day. Immediately numerous companies were incorporated, and large tracts of land were taken up for oil prospectors.

The death of Dr. Theo G. White, an active and able young geologist, of New York, July 7, is the cause of deep and sincere regret. There is a peculiar sorrow connected with the decease of such a young man, well equipped for his profession, who had a resasonable expectation and promise of many years of honorable service. We may present in the future a more suitable sketch of his life.

The Missouri Geological Survey.—Governor A. M. Dockery on May 23d appointed a new board of managers of the Bureau of Geology and Mines. On June 14th, the following gentlemen were elected as officers of the board: Prof. E. M. Shepard, Springfield, Mo., vice-president; Dr. E. B. Craighead, secretary; Col. H. H. Gregg, Joplin, Mo., and Dr. W. S. Allee, Olean, Mo. The Legislature ordered the removal of the survey headquarters to the School of Mines at Rolla. The state geologist will soon be appointed.

Doctor R. A. Daly has resigned his position as instructor in physiography at Harvard University, to accept a position on the Geological Survey of Canada. The work to which he has been assigned is the survey of a belt of country immediately adjoining the international boundary, on the Canadian side, and extending across the continent. The start was made about July 7th, near the foot of Mt. Baker, and Dr. Daly will keep pace with the party which is making a re-survey of the boundary. On account of this call, the expedition planned for Greenland and Baffin Land had to be abandoned, although arrangements down to the last detail had been made for it.

Mount McKinley. Mr. Robert Muldrow, in the *National Geographic Magazine* for August, gives an account of the highest mountain in North America, 20,464 feet. It is in Alaska, situated at the headwaters of the Sushitna and Kuskokwim rivers. The range is a portion of the Cordilleran system of North America. The mountain group is extremely rugged, and is covered with snow and ice to within 2,000 or 2,500 feet of the sea level, giving source to numerous glaciers. This mountain was first named and described in print by Mr. W. A. Dickey. Mr. Muldrow in 1898 made triangulation measurements from six different points. The average, for altitude, is as given above, and the latitude is 63° 5′ north, the longitude being 151° west.



GEOLOGICAL MAP OF THE ERUPTIVE ROCKS OF NORTHWESTERN CECIL COUNTY, MARYLAND.

THE
AMERICAN GEOLOGIST.

Vol. XXVIII. SEPTEMBER, 1901. No. 3.

THE BASIC ROCKS OF NORTHEASTERN MARYLAND, AND THEIR RELATION TO THE GRANITE.

Arthur Gray Leonard, Des Moines, Iowa.

PLATES XV-XIX.

INTRODUCTION.*

This paper contains the results of the study of a limited area of igneous rocks in which are found a number of different types ranging all the way from acid to ultra-basic. It is intended to show that these types are intimately associated in their geological occurrence and closely related in composition; that many of the types graduate into others by intermediate varieties, and that they probably represent facies of one original magma.

The study of these eruptive rocks was suggested by the late professor G. H. Williams, and the field work was commenced and carried on during the greater part of the month of June, 1893. At the same time the investigation of the granites lying just to the south was taken up by G. P. Grimsley and the results of his studies have already been published.† Accompanying his paper is a map, on which are represented not only the granites, but also the basic rocks lying to the north. The data concerning the distribution of the latter were furnished by the present writer and represent the views held after the preliminary survey of the field. Subsequent work has led to some changes in the boundaries of the gabbro and [illegible] and has brought to light additional rock types which are not represented on the previous map.

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*The writer is under special obligation to Dr. H. F. Reid, of the Johns Hopkins University, for the photomicrographs in this paper, which were made in the geological laboratory of the University. He is also much indebted to professor W. B. Clark and Dr. E. B. Mathews, of the same University, for helpful suggestions and for assistance rendered in many ways.

†The granites of Cecil county in northeastern Maryland. Jour. Cincinnati Soc. Nat. Hist., Vol. 17, pp. 59-67; 78-114. Cincinnati, 1894.

It was later found necessary to discontinue the study of the area and not until the autumn of 1897 was the work resumed. The region was then revisited under the auspices of the Maryland Geological Survey and the investigations were extended beyond the area previously studied.

GENERAL DESCRIPTION OF THE AREA AND ITS ROCK TYPES.

Location and Extent. The area of basic rocks treated in this paper lies within the belt of ancient crystallines which extends along the eastern flank of the Appalachian mountains, forming what is known as the Piedmont plateau. The formations which compose the Piedmont region are generally considered as pre-Cambrian and are therefore Archean and Algonkian in age. They are separated from the coast by the unconsolidated deposits of the Coastal plain. In Maryland the crystalline region is divisible into two portions: the western half consists of unfossiliferous and only slightly metamorphosed rocks which are of undoubted sedimentary origin; in the eastern division the rocks are wholly crystalline and show little or no certain evidence of clastic origin except in such infolded masses as the Deer Creek quartzytes and Peach Bottom slates. In this eastern portion of the Piedmont belt the rocks are chiefly gneisses, schists and marble, through which have broken eruptive masses of granite diorvte, gabbro, pyroxenyte and peridotyte. It is with one of these areas of eruptive rocks that this paper deals.

The rocks under discussion form a long, narrow belt extending in a general southwesterly direction from a point in Cecil county eleven miles west of the Delaware line, through Harford and into Baltimore county, to a point fifteen miles northeast of Baltimore. It has a length of about thirty-five miles and a width varying from two to three miles. The Susquehanna has cut its channel across this mass of igneous rocks, dividing it into two parts. This paper treats especially of that portion lying to the east of the river, in Cecil county, embracing an area of approximately twenty-two square miles. The types herein described are representative of those occurring throughout the entire belt and possess a special interest on account of the close association of the basic eruptives with the granites which border them on the south.

In addition to the larger mass there are three smaller ones. The "Stony Forest" area is the most extensive of these and is situated in Harford county, between five and six miles east of Bel Air. It has a length north and south of five miles and width of about three miles. Of the other two, which are not as large, one lies just north of Calvert (Brick Meeting House), extending a short distance into Pennsylvania, and the other about one-half mile northeast of Elkton, near the eastern border of the state. The latter, as shown by Chester, is a western prolongation of a larger area in Delaware.

AREAL DISTRIBUTION AND GENERAL DESCRIPTION OF ROCK TYPES.

The rocks embrace many different types distributed in a series of zones trending northeast-southwest. They include quartz-mica-hornblende-dioryte, quartz-dioryte, noryte, gabbro, pyroxenyte, peridotyte, serpentine and diabase. Occurring along the southern margin of the area next the granites are the quartz-mica-hornblende-diorytes, or tonalytes. Passing northward these are in general succeeded by coarse-grained hornblende-diorytes, which commonly carry considerable quartz in good sized grains. These hornblendic rocks are in turn followed by norytes and gabbros, which are bordered on the north by the serpentine mass. The latter lies along the edge of the area and extends across the line into Pennsylvania. Coarse pyroxenytes are found along the boundary between the noryte and serpentine and both non-feldspathic types occur in dykes within the gabbro and noryte. (See map, plate xv.)

It is not possible to draw any sharp line of separation between the granite and tonalyte, for these are connected by intermediate types and thus graduate the one into the other. The tonalyte varies considerably in appearance according to the fineness or coarseness of the grain and the relative proportion of the light and dark constituents. As a rule it is a medium coarse-grained, granular rock of a grayish color. Dark patches or segregations of finer grained material rich in biotyte frequently occur in these tonalytes as well as in the granites. The former is composed of lime-soda feldspar, quartz, hornblende, biotite and a little orthoclase. Magnetite, apatite, zircon, sphene (titanite) and garnets are present as accessory constituents, and more or less secondary epidote is almost always found.

The hornblende-dioryte is a common type throughout the area. It is a coarse-grained aggregate in which striated feldspar and black, compact hornblende can be readily distinguished with the unaided eye. More or less quartz is usually present and not uncommonly a little accessory biotite. On a fresh surface the rock has a mottled appearance due to the white feldspar standing out against the dark hornblende. But when it has been much weathered the surface becomes much pitted on account of the removal of the plagioclase. When quartz forms one of the constituents the other minerals weather out and leave the former projecting, giving the rock a rough exterior which is highly characteristic of the quartz-dioryte. The abundance of blue quartz is a noticeable feature of this type. It is commonly in good sized grains ranging from one-eighth to one-sixteenth of an inch (one and a half to three millimeters) in diameter. With an increase in the amount of biotite this rock passes over into tonalyte.

The most abundant rock type in the whole area is probably the noryte, with which the gabbro is closely associated. The constituents of the former rock that are readily distinguishable are a greenish black or reddish brown hypersthene, often with a bronzy, metallic luster, and fresh striated feldspar. In addition a little secondary diallage is usually present. The noryte is a medium coarse-grained, granular rock, often with a crumbly appearance due to its loose texture. It varies in color from gray to almost black, but the light colored varieties are the more prevalent. A noticeable peculiarity of this type is the development of green hornblende along certain planes where there has probably been more or less stress. These green bands, which have a width of several millimeters, usually stand out conspicuously on a weathered surface. In this region the norytes are more abundant and important than the gabbros. They differ from most of the other types of the area in being as a rule remarkably fresh and unaltered. One specimen each of quartz noryte and olivine noryte was collected but these varieties are rarely found. Still more interesting is the occurrence of a saussurite noryte in which the feldspar is completely altered to zoisite and the hypersthene partially changed to fibrous hornblende. A porphyritic variety with large phenocrysts of diallage occurs at the Mount Hope church. With an increase in the amount of diallage the noryte passes over into hypersthene-gabbro. While this rock is in general more compact and somewhat darker in color than those just described, it often bears a close resemblance to them. The diallage is seldom more abundant than the orthorhombic pyroxene and the latter is always present in large amount.

If compared with the diorytes occurring along the southern border of the area, the hypersthene-gabbros, as well as the norytes, are seen to be noticeably finer in grain. Where the gabbro outcrops at some points, notably along Octoraro creek and on the Susquehanna, it is seen to have been considerably altered and bears slight resemblance to the original rock. The plagioclase is no longer bright and transparent, but is changed to a dull, opaque saussurite, while the pyroxene has also altered into a greenish, fibrous hornblende. The resulting rock, which is a typical saussurite gabbro, has a light greenish color and a mottled appearance due to the white and green minerals composing it. Olivine gabbro is of rare occurrence in this region, only a few specimens being found.

By the alteration of the pyroxene to secondary hornblende the hypersthene-gabbro has in some cases been changed into gabbro-dioryte or metagabbro. But this metamorphic process does not appear to have gone on very extensively and these secondary diorytes are comparatively rare.

Numerous diabase boulders were observed just east of Rising Sun, and at various points near the railroad between that locality and the state line. These are doubtless derived from the trap dike traced by H. C. Lewis through southeastern Pennsylvania to the Maryland boundary, which it crossed not far from Sylmar station.* The rock is very fine-grained and compact.

Pyroxenytes and peridotytes occur in dikes and lens-shaped masses in the noryte and gabbro. The former is also abundant along the serpentine border, where it appears to be a basic facies of the noryte, into which it merges by intermediate varieties. This non-feldspathic type is a coarse-grained aggregate in which the constituents can readily be distinguished: they are a reddish brown hypersthene with which is associated a greater or less amount of greenish diallage. These pure pyroxene rocks are found in the vicinity of Oakwood, along the state line north of Rising Sun and at several other localities.

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*American Philosophical Society, May 15, 1885, 19 pp.

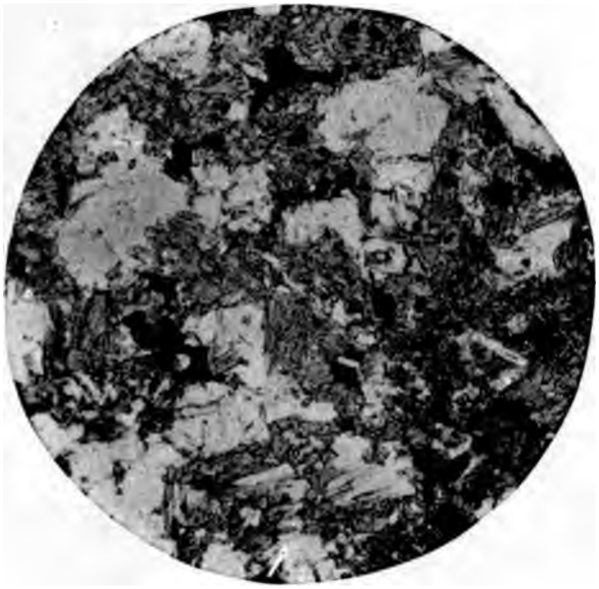
The peridotytes are likewise coarse-grained and frequently have a porphyritic structure. They contain olivine in addition to the pyroxenes. The largest mass is near the Mount Hope church, one mile and a half northeast of Rising Sun, where the rock has the peculiar mottled appearance known as poikilitic. due to the dissemination of small grains of greenish olivine through large individuals of pyroxene. When the light is reflected from a cleavage surface these grains form dull spots. Other localities for these olivine rocks are at the Oak Grove schoolhouse, two miles northwest of Rising Sun; along Octoraro creek above the paper mill, and beside the railroad just south of Conowingo.

The serpentine borders the noryte-gabbro mass on the north. It is known as the "State Line serpentine" on account of its occurrence along the boundary between Maryland and Pennsylvania. The greater portion of the mass lies across the line in Chester county. The southern margin coincides approximately with the line as far west as Octoraro creek, where it bends to the south and enters Cecil county. The area has a length east of the Susquehanna river of seventeen miles and an average width of one mile. Between Conowingo creek and the river there is another small mass of serpentine which extends across from Lancaster county, Pennsylvania. The region over which this rock outcrops presents an uninviting and desolate apeparance, making very appropriate the term "barrens," which is often applied to it.

PETROGRAPHICAL DESCRIPTION OF ROCK TYPES.

DIORYTE.

The diorytes are confined to the southern edge of the area where they form a belt varying from one to one and a half miles in width, the widest portion being near the eastern end.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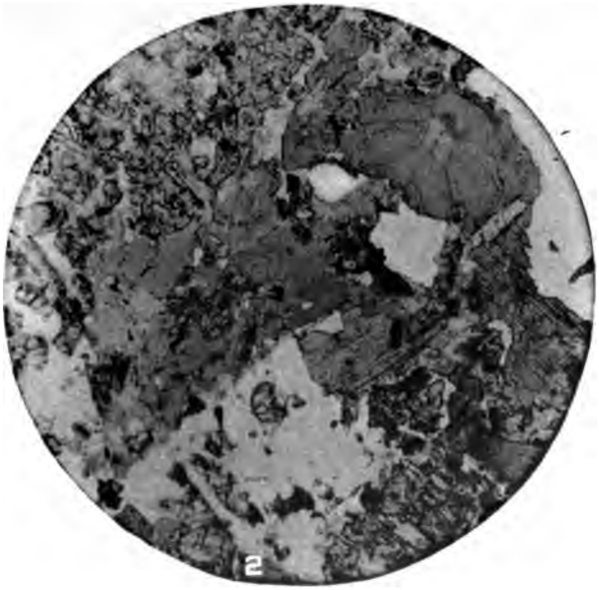
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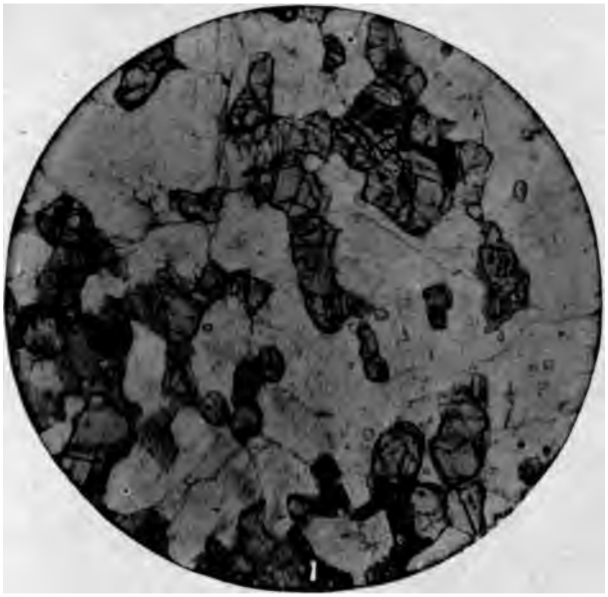
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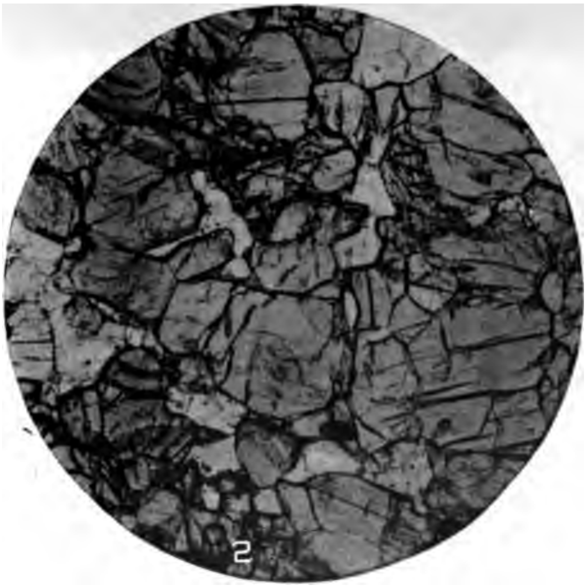
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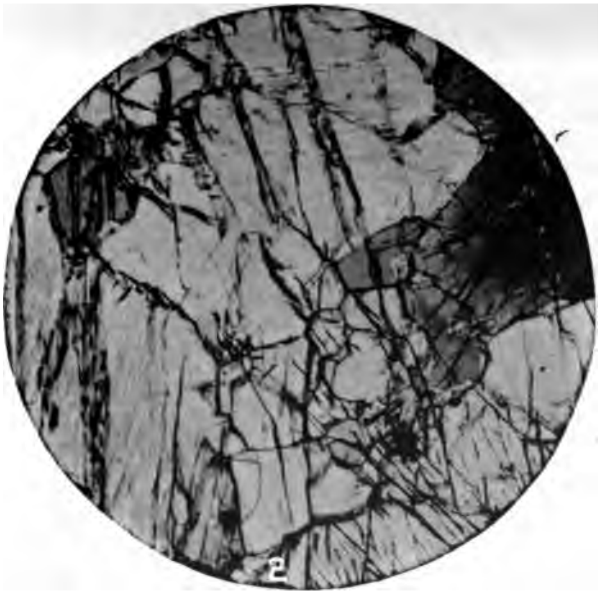
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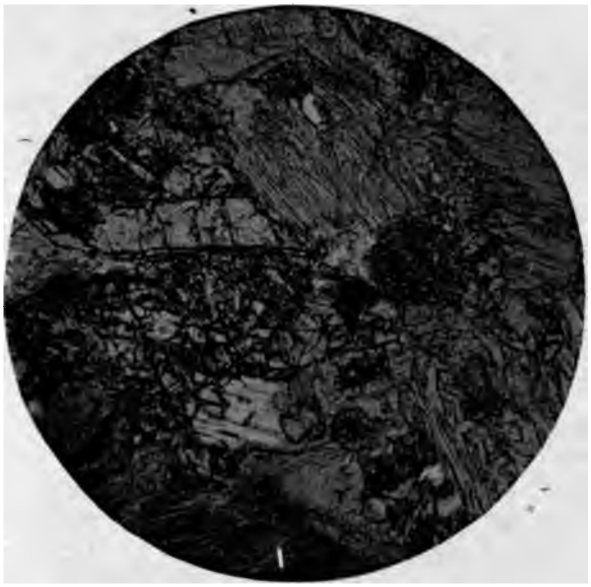
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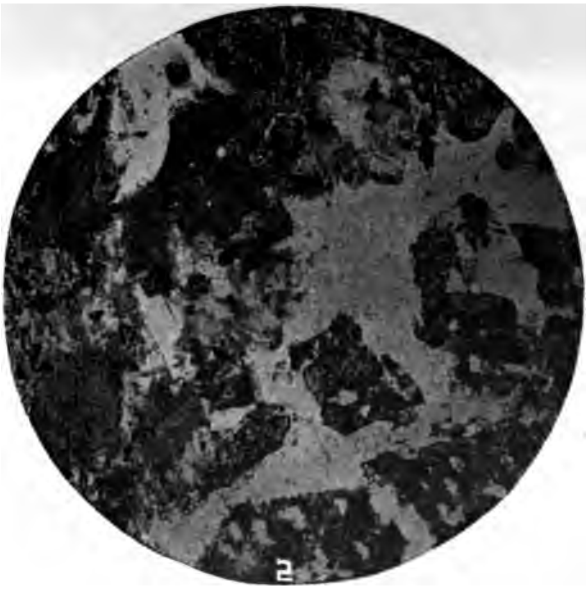
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They are found best developed in Cecil county, where they lie between the granites on the south and the gabbros and norytes on the north. While the diorytes are found west of the Susquehanna river in Harford county, they do not there form so well defined a zone bordering the main eruptive mass.

It is not possible to draw any sharp line of separation between the granite and dioryte. On the south this rock passes by intermediate types into the biotite-granite of the Rowlandsville area, which, as will be shown later, has very much the composition of a dioryte. Along the northern border the diorytes are intimately associated with the gabbros and norytes, but the transition from one to the other is not well marked, as in the case of the granites, and intermediate types between the pyroxene and hornblende rocks are rare.

Two varieties of dioryte are present in the area, namely, a quartz-dioryte and a quartz-mica-hornblende-dioryte. The former is confined for the most part to the northern portion of the dioryte belt, next to the norytes; the latter is found mostly in the southern portion where it passes into the biotite-granite. For the purpose of description it will be convenient to consider these separately, taking up first the most acid variety.

Quartz-mica-hornblende-dioryte. This rock is found at many points between Rising Sun and the Susquehanna; it is abundant along Stone run, extending south of that stream as far as the Harrisville road; large boulders of it are numerous at the foundry, and at Harrisville, and outcrops occur at the junction of Stone run and Octoraro creek, at Porter Bridge, and along the road leading westward from the bridge to the Rowlandsville road. Across the Susquehanna river in Harford county good localities for this rock are near Darlington and one mile east of Thomas Run P. O., on the south side of Deer creek.

This dioryte varies considerably in appearance according to the fineness or coarseness of the grain and the relative proportions of the light and dark constituents. As a rule it is a medium coarse-grained, granular rock of a grayish color, such as that occurring south of Stone run. It is very granitic in appearance and might easily be mistaken at first sight for a hornblende-granite. The dioryte of the Porter Bridge region is darker in color, often fine-grained, and the hornblende usually occurs in good sized allotriomorphic individuals which occasionally reach a length of over one-quarter of an inch (six millimeters). This tendency toward the development of a porphyritic structure is quite marked in some cases.

Dark patches or segregations of finer grained material rich in biotite frequently occur in these rocks. No evidence was found for considering them as inclusions rather than segregations. As already stated, the dioryte varies considerably in grain within short distances and these dark patches appear to be merely accumulations of such fine grained material. These segregations, which are also found in the Rowlandsville granite, do not increase in size or number as the diorite mass is approached. They will be considered more at length in another place.

The mineral constituents of this dioryte which can readily be distinguished are hornblende, biotite, plagioclase, quartz, and a little orthoclase. Some accessory magnetite and apatite is usually present, together with a little zircon and sphene (titanite). Garnets are not uncommon and epidote and chlorite occur as secondary minerals. Mineralogically these diorytes containing biotite and quartz may be classed as tonalytes, though they contain a relatively larger proportion of the ferro-magnesian constituents than the typical tonalyte from Adamello, described by vom Rath,[*] and are poorer in silica. Through a decrease in the hornblende and a corresponding increase in the biotite they pass into the biotite-granite or mica-dioryte and by a loss of biotite and corresponding increase of hornblende they graduate into the quartz-dioryte. Such transition types are of common occurrence.

The *feldspar* of these quartz-mica-hornblende-diorytes is mostly acid labradorite, though some orthoclase is also present. Stauroscopic measurements on cleavage pieces gave —5° to —6° on $0P$ (001) and —15° to —17° on $\infty P \breve{\infty}$ (010). With the loss of the hornblende and increase in the amount of feldspar and quartz the plagioclase grows more acid and in the biotite-granite (mica-dioryte) it was found to be oligoclase. The feldspar is usually finely striated, due to repeated twinning according to albite law. Occasionally one set of striations is crossed by another nearly at right angles, indicating the presence of twinning according to both the albite and pericline laws. Zonal structure is frequently found but is more or less obscured by the alteration which has taken place in the feldspar. The plagioclase is quite free from inclusions and differs in this respect from that of the gabbros and norytes.

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[*] Zeit. der deutschen geol. Gesellsch., XVI, 1864, p. 249.

The alteration of the feldspar to epidote has gone on very extensively. All stages of this progress of epidotization were observed from that in which the change has only just commenced to that in which the epidote has almost replaced the original mineral. At first the plagioclase contains only small scattered crystals and the twinning lamellæ are still evident. As the alteration progresses the epidote crystals become more numerous and crowded together; larger individuals also appear, often with no regular crystal outline. The feldspars in the sections now appear opaque on account of the accumulation of minute, closely compacted crystals which fill them and prevent the light from passing through. The hand specimens show that the feldspars have lost their glassy appearance and become dull and white. The crystals of epidote have no definite arrangement, but are distributed in an irregular manner through the host. In most instances the outer edge of the crystal is free from epidote, the latter being confined to the inner portions of the feldspar individuals.

The *hornblende*, which is compact and green, is, next to the feldspar, the most abundant constituent. It seldom occurs in well defined crystals, but is usually in imperfectly developed individuals or confused aggregates. Occasionally, as in some of the diorytes near Porter Bridge, the prismatic faces are well developed and give rise to columnar forms which on weathering stand out upon the surface. Twins are not uncommon, the twinning plane being the orthopinacoid. One basal section of such a twin showed several twinning lamellæ intercallated between the two larger halves.

The pleochroism is very pronounced and does not differ from that usually found in hornblende.

Quartz is an abundant constituent of most of the diorytes. It is commonly in good sized grains readily distinguishable in the hand specimens and usually of a beautiful blue color. The larger individuals not infrequently show shattered borders due to mechanical deformation, and this granulation may effect the entire grain, which is broken into pieces. These unite to form a mosaic of interlocking fragments which still preserve the outline of the original grains. The quartz is filled with numerous very minute fluid inclusions. Occasionally it contains in addition many fine needles, probably of rutile, but they are too small for the satisfactory determination of their character.

Biotite occurs in plates or lamellæ without crystal boundaries. It is very strongly pleochroic, the rays parallel to the cleavage (𝔟 and 𝔠) being dark brown, and those at right angles (𝔞) light yellow. Inclusions of apatite, epidote and magnetite are common in the biotite.

As accessory constituents magnetite and apatite are almost always present, and titanite occurs occasionally. The epidote is never absent from these diorytes and though it may in some instances be primary it is usually a secondary product developed during the alteration of the feldspar. It commonly occurs in well defined crystals, irregular grains or compact aggregates.

Quartz-dioryte. As already stated the quartz-diorytes occur chiefly along the northern border of the dioryte belt next the norytes and gabbros. As one passes north across the area the dioritic rocks are seen to grow darker in color, and there is a decrease in the amount of biotite accompanied by a corresponding increase in the hornblende. The quartz-dioryte and the tonalyte are thus connected by intermediate types and graduate into each other. By a decrease in the amount of quartz this rock passes into a true hornblende-dioryte.

Among the many localities where the quartz-dioryte occurs the following may be mentioned; north of Rising Sun along Stone run; at McKinsey's mill on the same stream, where it outcrops near the bridge, and along the Susquehanna one mile below Conowingo. In Harford county it is found one half mile south of Bel Air, along Deer creek, one and half miles southwest of Darlington and at numerous other points.

The quartz-diorytes have a medium coarse-grained texture and are dark, almost black, in color. On a fresh surface they have a mottled appearance due to the black hornblende standing out against the white feldspar and quartz. The minerals composing the quartz-dioryte are plagioclase, quartz, hornblende, and occasionally a little accessory biotite. Other accessory constituents shown under the microscope are magnetite and apatite together with a little titanite (sphene) and zircon. Epidote and chlorite are common secondary minerals.

The feldspar is acid bytownite. Stauroscopic measurements showed extinction angles on oP (001) of —18° to —20° and on the $\infty P \breve{\infty}$ (010) of —30°. The specific gravity as determined by means of the Thoulet solution was in one specimen 2.71, in another 2.72.

Quartz is occasionally present in small amount and cannot be detected without the aid of the microscope. The rock thus passes into a true hornblende-dioryte with a little accessory quartz, and this type is very basic in composition as shown by the accompanying analysis. As a rule, however, the quartz occurs in good sized grains and is blue in color, resembling in all respects that found in the tonalytes. The hornblende does not differ from that already described under the quartz-mica-hornblende-diorytes.

Metamorphic changes. The diorytes have undergone considerable alteration through the extensive epidotization of their feldspar. The various stages in this process can be traced from where there are only scattered crystals of epidote and the plagioclase is still clear and bright to where, as an opaque white mass, it is almost wholly replaced by a compact aggregate of separate epidote individuals. In no instance was complete replacement observed to have taken place, although often only slight traces of the original feldspar remain. This is genetically the same process as the saussuritization of the feldspar that has gone on so extensively in the gabbros and has resulted in the replacement of that mineral by zoisite. In the latter case no iron is required, while in the formation of epidote this element is necessary. It is doubtless derived from the hornblende, or in case of the dioryte containing biotite some of the iron may be supplied from the latter source.

The following very complete analyses of both varieties of the dioryte were made by Mr. W. F. Hillebrand of the United States Geological Survey. I is an analysis of a typical quartz-mica-hornblende-dioryte from near the foundry on Stone run. This rock, which is quite granitic in texture and appearance, is composed of labradorite, quartz, hornblende and biotite, together with a little magnetite, apatite, titanite (sphene) and ortho-

and a linear arrangement, thus giving the rock a well marked banded appearance.

A characteristic feature of the norytes is the development of secondary hornblende along certain planes. This shows itself in narrow green bands or lines traversing the rock in various directions and standing out on weathered surfaces. When a number of these are present they give the rock a greenish color.

Almost without exception the norytes are remarkably fresh and unaltered. They are readily seen with the unaided eye to be composed of a clear, glassy feldspar and a reddish-brown or dark hypersthene which may or may not possess a bronzy lustre. In addition to these essential constituents the rock is shown by the microscope to contain a little accessory diallage, together with magnetite, apatite and secondary hornblende. The magnetite is by no means abundant and is often absent from the sections.

The feldspathic constituent is *bytownite* which was found to be slightly more basic than that of the diorytes. It gave extinction angles as high as —22 on oP(001) and —31° on $\infty P \breve{\infty}$ (010). The specific gravity as determined by the Thoulet solution was 2.74. This mineral seldom exhibits crystal outlines but occurs in rounded or irregular grains. As in the diorytes the feldspar is commonly finely striated, though in some cases these twinning lamellæ are wanting. Abundant inclusions, like those so characteristic of the plagioclase of the gabbros, are usually found.

The *pyroxene* is represented almost wholly by the orthorhombic variety, hypersthene. This occurs in grains that are more or less rounded and often elongated in the direction of the vertical (c) axis. The most striking characteristic of this constituent is its marked and often brilliant trichroism. The ray vibrating parallel to the brachydiagonal axis (a ray) is reddish brown, that parallel to the macrodiagonal axis (b ray) is light greenish yellow; while the one vibrating parallel to the vertical axis (c ray) is green. There is a well developed cleavage parallel to the unit prism, and in addition distinct partings parallel to the macropinacoid and brachypinacoid. These show themselves in basal sections as two sets of cracks at right angles to each other and forming angles of 45° with the cleavage lines

Sections in prism-zone showed an extinction parallel to these lines.

Pieces cut parallel to the macropinacoid give in converged polarized light two optic axes and a bisectrix in the field, showing that the brachydiagonal axis is the acute bisectrix and that the mineral is positive. These optical properties establish the fact that this is hypersthene and not enstatite, bronzite or diallage. The specific gravity is 3.50.

The inclusions, to which the hypersthene owes its bronzy, metallic lustre, are commonly quite abundant but may be entirely absent. They do not differ from those so often described as occurring in this mineral.

Diallage is usually present in the norytes as an accessory constituent. It is readily distinguished from hypersthene by its lack of pleochroism. It occurs better crystallized than the latter mineral, being found in irregular grains which have a green color in transmitted light. In a specimen from near the Mount Hope church the diallage formed large porphyritic crystals with a prismatic habit, imbedded in a groundmass of hypersthene and feldspar. The specific gravity is 3.28.

The other accessory constituents are magnetite and apatite. The former is not always present and is usually not very abundant.

Metamorphic changes in the norytes. For the most part these rocks have undergone but little alteration. The most noticeable change is the one already mentioned, namely, the transformation along certain planes of the pyroxene into hornblende. In the hand specimen these planes appear as narrow green bands or lines traversing the rock in various directions, often parallel, and when examined under the microscope they are seen to have been formed by the alteration of the original constituents. The lines cross the slide from one side to the other, cutting across many individuals both of the pyroxene and bytownite. Along these zones the hypersthene has been changed into a colorless, or light green, fibrous hornblende. A narrow band of this secondary hornblende frequently passes through several hypersthene individuals which are elsewhere entirely unaltered. The feldspar is also transformed along these lines into a greenish mineral resembling chlorite. Occasionally small patches of zoisite are developed. Where these planes have cut across twinning lamellæ it was observed that no displacement of these had taken place and hence there could have been no shearing or slipping. The minerals traversed by the planes show no evidence of having been shattered. The alteration seems, in all cases, to have taken place along certain planes of stress produced by dynamic forces. Along these planes the rock has been subjected to a strain which has resulted, not in the mechanical deformation of the constituents, but in the change of their mineralogical character.

In the same rock the hypersthene is sometimes surrounded by a double rim of hornblende, the inner portion colorless, the outer green and more compact.

Another metamorphic change in the noryte is the alteration of the feldspar into saussurite. In the study of these saussuritized rocks it is usually impossible to determine whether the original type was a gabbro or noryte, since all the pyroxene has been transformed into hornblende. In a specimen collected on the west side of Octoraro creek just south of the "horseshoe bend" remnants of the hypersthene still remained in the fibrous hornblende, leaving no doubt that in this instance at least the rock was a noryte. The orthorhombic pyroxene had lost much of its color, but was yet slightly pleochroic and contained the characteristic tabular inclusions. The feldspar had been entirely replaced by a whitish or greenish, opaque substance composed almost wholly of zoisite. In thin sections this mineral was colorless, with a rather high index of refraction but low double refraction, the interference colors being sometimes dull gray, more often a beautiful ultramarine blue.

While it is not an uncommon thing for the gabbros to have their feldspar thus altered to saussurite, this is, so far as known, the first instance reported of a like alteration in the norytes. We have here a true saussurite noryte composed of zoisite and partially uralitized hypersthene. It is not improbable that many of the rocks described later as saussurite gabbros are really norytes.

Five varieties of the noryte occur within the area under consideration, namely:

1. Noryte.
2. Porphyritic noryte.
3. Quartz-noryte.

4. Olivine-noryte.
5. Saussurite noryte.

The first named, made up almost wholly of hypersthene and bytownite, is by far the most common type, the other varieties being of rare occurrence.

The porphyritic facies was found near the Mount Hope church and consisted of a rather fine-grained groundmass in which were imbedded large phenocrysts of diallage.

The specimens of quartz-noryte were collected from a boulder near the junction of Stone run and Octoraro creek. It resembles very closely the quartz-noryte found at Mount Hope, near Baltimore, and described by U. S. Grant.[*] The quartz appears in limpid, colorless, or light blue grains, sometimes with a diameter of one-eighth of an inch (3 millimeters). It is filled with slender, hair-like needles, probably of rutile, though this could not be definitely determined. This quartz has every appearance of being an original constituent and not a product of replacement or infiltration.

The almost entire absence of quartz from the pyroxene rocks of this area is noteworthy. It has already been shown to be an important constituent in the closely associated diorytes. Moreover, the gabbros near Wilmington, Delaware, not more than twenty-five miles to the east, are known to contain an abundance of quartz. But in this region the gabbros and norytes only rarely carry any free silica.

A typical noryte (IV) from one mile west of the Oak Grove schoolhouse was analyzed by Mr. W. G. Hillebrand of the U. S. Geological Survey, with the following results. The rock is very fresh and composed of bytownite and hypersthene with some accessory magnetite.

IV.

SiO_2	48.02	MnO	.18
TiO_2	.23	CaO	11.42
ZrO_2	none	SrO	none
Al_2O_3	20.01	BaO	none
V_2O_3	.02 (019)	MgO	10.05
Cr_2O_3	.03 (027)	K_2O	.05
Fe_2O_3	1.13[†]	Na_2O	.51
FeO	7.29[†]	LiO_2	trace
NiO, CoO	.01	H_2O below 105° C.	.10

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[*] Johns Hopkins University Circulars, No. 103, Feb., 1893.

[†] Subject to correction for influence of possible pyrrhotite.

H_2O above 105° C	.57	Cl	[illegible]
P_2O_5	trace	F	[illegible]
FeS_2	11.06[†][§]		[illegible]
CO_2	.25	Sp. gr.	[illegible]

HYPERSTHENE-GABBRO.

This rock, as already stated, is intimately associated with the noryte, into which it everywhere passes through the increase in the amount of diallage present. It is impossible to draw any line between these two types either in their geological occurrence or in their mineralogical composition. They occupy the same area and no attempt has been made to separate them in plotting the distribution of the different rocks. The gabbro is less abundant than the noryte and where it does occur it is always rich in hypersthene. It is to be regarded as a mineralogical facies of the prevalent noryte. Fine exposures are to be seen along the railroad south of Conowingo, where it has been blasted to make room for the track. Outcrops also occur along Octoraro creek above the mouth of Stone run, and in the vicinity of Mount Hope church, while boulders of it are abundant at many points throughout the area, notably along the Harford turnpike for a mile northeast of Reckord and east of Conowingo on the Porter Bridge road.

The gabbro resembles the noryte in color, ranging from light shades in those varieties rich in feldspar to dark colored where the pyroxene is the more prominent constituent. As a rule they are more compact and do not have the crumbly appearance of many of the norytes. In texture they are medium to fine-grained. A very coarse-grained facies of the gabbro was observed a short distance above the paper mill on Octoraro creek, some of the constituents having a length of nearly one inch (26 millimeters).

In the hand specimens the minerals that can be readily distinguished are feldspar, hypersthene, and diallage, while under the microscope the rock is seen to contain some accessory magnetite and apatite. Olivine was found in only two specimens.

The feldspar is bytownite and is in all respects identical with that of the norytes already described. It has been more or less altered to zoisite and is often wholly changed into saussurite. In this regard it differs from the plagioclase of the associated pyroxene rocks which is as a rule very fresh and unaltered.

[†] Sulphur calculated as FeS_2, but exists as pyrrhotite or other sulphide soluble in HCl

[§] Perhaps mainly pyrrhotite.

It is not necessary to add anything more to the description already given of the diallage and hypersthene. The former mineral is not present in large amount and while it varies considerably it is rarely more plentiful than the orthorhombic pyroxene. The former is by far the most important of the ferromagnesian constituents occurring in these basic rocks. Magnetite is seldom absent and apatite, while frequently found, is by no means abundant.

Olivine is rare in the gabbros and norytes of this region, having been observed in only two specimens, one from the small area northeast of Elkton, the other from near Oak Grove schoolhouse, one and one-half miles northwest of Rising Sun.

Metamorphic changes in the gabbro. The gabbro of this area has undergone considerable alteration which has resulted in the change of its feldspar into saussurite and its pyroxene into hornblende. The metamorphosed rock thus produced is a typical saussurite gabbro. The saussurite is found under the miscroscope to be composed almost wholly of crystals and irregular grains of zoisite. Some good sized patches of the latter gave no evidence, even with the highest power, of being formed of small individuals. On the other hand, the larger masses are frequently seen to be not single crystals but aggregates made up of separate grains and crystals. Prisms of zoisite without terminal faces are quite common. They show the perfect cleavage parallel to the vertical axis, the cross jointing at right angles to this, the parallel extinction and the biaxial interference figure with very small optic angle. The mineral is colorless, has a high index of refraction, weak double refraction, and is optically positive. In thin sections the saussurite is as a rule quite clear and transparent, since the zoisite composing it is in good sized grains and crystals, but occasionally it becomes opaque. As already stated, the pyroxene of these gabbros has been changed into fibrous hornblende. The two chief constituents of the saussurite gabbro are therefore secondary hornblende (smaragdite) and saussurite. Some chlorite and a little secondary quartz are commonly present.

GABBRO-DIORYTE (METAGABBRO).*

Like the saussurite gabbros these rocks are formed by the metamorphic changes which have gone on in the hypersthene gabbros, but in this case only the pyroxene has been altered, the greater portion of the feldspar remaining unchanged. There does not appear to have been a very extensive development of the gabbro-dioryte in this area and consequently the rock is not very abundant. Of the few localities where it was observed the best is in the vicinity of the Mount Hope church, one and one-half miles northeast of Rising Sun; it is here found in scattered boulders and also exposed in the railroad cut near by.

The gabbro-dioryte may be distinguished from the true dioryte both by its finer grain and by its dark greenish color. The latter characteristic also serves to separate it from the gabbro and noryte which do not have the greenish tinge imparted by the secondary hornblende when present. The metagabbro is commonly more compact than many of the pyroxene rocks.

In the hand specimen the unaided eye can readily distinguish a clear, usually fresh, colorless or white feldspar and a greenish, fibrous hornblende with a satiny lustre. The microscope shows that some magnetite, apatite and epidote are also present. The feldspar is bytownite as in the original gabbro and does not differ from that already described in connection with that type. It has not suffered much alteration and is as a rule clear and fresh; occasionally, however, a little secondary epidote is developed in the plagioclase. The hornblende is the common green pleochroic variety. It never shows crystal outlines but occurs in fibrous masses or forms aggregates composed of numerous small individuals. When the hornblende is fibrous, as is commonly the case, these individuals are often colorless on the inside and surrounded by a green and more compact border

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*The term gabbro-dioryte was first employed by A. E. Törnebohm (Neues Jahrbuch f. Min. etc., 1877, p. 391), was later applied by Williams to the secondary diorytes of the Baltimore region, and has since come into quite general use. Recently, however, it has been suggested that for much altered rocks which are of known igneous origin the term "meta" be prefixed to the name of the original rock. In accordance with this usage an altered gabbro would be designated a metagabbro instead of a gabbro-dioryte. (Report of Committee on Nomenclature of Igneous Rocks, appointed by the Director of the United States Geological Survey.)

The formation of hornblende from pyroxene is by no means uncommon and the alteration need not be described here.

DIABASE.

At several points between Rising Sun and Sylmar station, on the state line, boulders of diabase were found. These doubtless belong to the dike described by H. C. Lewis and traced by him as far as the Maryland line which it crosses probably a little west of Sylmar.* The dike extends in a southwest direction through southeastern Pennsylvania, where it was followed for a distance of seventy miles. The width at some points was found to be one hundred feet. Its age is thought by the above writer to be late Triassic, since it cuts rocks of the latter age.

Diabase boulders are quite abundant just across the railroad east of Rising Sun and south of the wagon road; they are also found in the fields south of the railroad at other points between here and Sylmar. G. P. Grimsley states that a diabase dike was traced for nearly a mile south of the town of Liberty Grove. Since these scattered boulders are in general arranged along a line having a northeast-southwest direction and extending from the state line to the vicinity of the town above mentioned, the evidence seems to be sufficient to warrant the representation of it which has been made upon the map.

The rock is a fine-grained diabase which has a metallic ring when struck with the hammer. The weathered surface is covered with a thin coating of red clay. Under the microscope the rock is seen to be composed of lath-shaped crystals of feldspar, irregular grains of augite and a little magnetite.

PYROXENYTE.

With a decrease in the amount of feldspar the noryte and hypersthene-gabbro pass over into rocks composed wholly of pyroxene. These pyroxenytes are common at many points along the border next the serpentine, where they are closely associated with the latter rock and also with the peridotyte. Intermediate types between the pyroxenyte and noryte are often found. Among the localities for the pure pyroxene rock may be mentioned the following: in the vicinity of Oakwood, especially just east of town at the Mount Pleasant academy;

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*Proc. Amer. Philos. Soc., May 15, 1885, pp. 438-456.

along the serpentine border south of Rock Springs and [illegible] and the Mount Hope church; near the point where the [illegible] branch of [illegible] run crosses the state line, and along the [illegible] near the cotton-house below Conowingo. At the two last named localities the rock is exposed in outcrops and associated with [illegible] and serpentine. Near Conowingo it [illegible] dikes in the norite. These pyroxenytes are coarse granular aggregates composed of rounded grains of diallage and hypersthene. In a hand specimen it is easy to distinguish these two minerals which make up the bulk of the rock. The diallage is dark green, almost black, while the hypersthene is commonly a reddish brown. The constituents often reach a length of from one-quarter to one-half an inch (7-13 millimeters) and sometimes more. They vary in color from the dark green, almost black rocks rich in diallage to dark purple or reddish brown ones composed almost entirely of hypersthene.

The hypersthene resembles that already described as occurring in the norites and gabbros, though in the pyroxenytes the tabular inclusions were not observed. The mineral is readily distinguished under the microscope by its brilliant pleochroism.

The diallage is green in transmitted light and shows no pleochroism. The columnar structure so characteristic of bronzite and enstatite is often present in great perfection, the mineral being composed of thin columns or prisms grown closely together, which give the diallage a coarsely fibrous appearance. The prismatic cleavage is well developed but even more noticeable is the very distinct parting parallel to $\infty P \bar{\infty}$ [illegible]. Small cleavage pieces parallel to the orthopinacoid gave in converged polarized light an optic axis which had an eccentric position in the field. The presence of this interference figure, together with the inclined extinction (40°) shows the mineral to be diallage and not bronzite or enstatite. Basal sections also show an optic axis surrounded by several colored rings.

The only other constituents besides those already given are an occasional grain of magnetite and sometimes a little feldspar. As the latter increases in amount the rock graduates into a norite. A common intermediate type is a [illegible] rock very rich in hypersthene and in which the plagioclase forms about one-tenth of the entire mass.

Two varieties of pyroxenyte occur in northeastern Maryland, namely, a hypersthene-diallage rock (websteryte) and a pure hypersthene rock (hypersthenyte.) The latter, which has a coarsely granular texture, is the more abundant, being found at a number of different points, but especially in the vicinty of Oakwood and a short distance south of Conowingo. At the former locality the hypersthenyte seems to occur as a facies of the noryte, along the border between the latter and the serpentine, while at the last named locality the rock forms a dike or dikes in the noryte. In places the hypersthenyte contains some olivine and thus passes into peridotyte. The websteryte is found near Oakwood and at various points, but perhaps the best locality for this rock is one and a half miles west of Sylmar. At this same place there is an outcrop of peridotyte along the road near the crossing of the west branch of Stone run. Like the other pyroxenyte type the websteryte is frequently found near the edge of the noryte mass, closely associated with the serpentine. The rock is a very coarse-grained aggregate, the allotriomorphic individuals often measuring one-quarter of an inch (6 to 7 millimeters) in diameter. Both varieties of pyroxenyte are remarkable for their freshness, many of them having undergone no alteration whatever.

Pure pyroxene rocks, which are quite abundant in Maryland, were first described from here by G. H. Williams* who recognized two well marked types as occurring within the state, namely, a hypersthene (or bronzite)-diallage rock and one composed of the same orthorhombic pyroxene and diopside. To these two types a third must now be added, namely, one composed almost wholly of hypersthene—the hypersthenyte.

The first type above mentioned occurs in Baltimore, Harford and Cecil counties, Maryland, and in Chester county, Pennsylvania. The latter occurrence is described by F. D. Chester, who states that the rock consists mainly of bronzite and diallage which are usually much altered.† The second type, the bronzite-diopside aggregate, occurs near Hebbville P. O., Baltimore county, and resembles the pyroxenyte from near Webster, North Carolina, assumed as the type locality bv Williams.

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*Amer. Geol., July, 1890, pp. 35-49.

†Ann. Rept. Geol. Surv., Penn., for 1887, p. 95, 1889.

[illegible] larger [illegible] pyroxene and containing [illegible] Hunt from Kong- [illegible] Dana and G. H. Wil- [illegible] New [illegible] Hutton from [illegible] New Zealand [illegible] Turner from Aus- [illegible] the pyroxenite is associated with [illegible] and [illegible] from Madagascar.

[illegible] should be added concerning the usage of [illegible] The name was first used by T. [illegible] intrusive rocks composed [illegible] pyroxene in the [illegible] New [illegible]*

[illegible] propose that the term pyroxenite [illegible] designate those igneous rocks free from [illegible] and [illegible] now generally accepted [illegible] composed wholly or chiefly of pyro- [illegible] in various localities in [illegible] with very little [illegible] rocks at Monte [illegible] again note rocks of this variety [illegible] from [illegible] specimens carried some [illegible] these are the only localities [illegible] is found.

[illegible] was first applied [illegible] sometimes [illegible] now more commonly used [illegible] reserved for those [illegible]

[illegible]

[illegible]

still in its early stages cores of pleochroic hypersthene may yet be seen surrounded by secondary hornblende, but commonly the former mineral has entirely disappeared. More or less iron oxide separates out during the change and is scattered through the mass in small grains of magnetite.

The following analysis (V) of a fresh and typical websteryte from Oakwood was made by Mr. W. F. Hillebrand, of the United States Geological Survey. The rock is a very coarse-grained aggregate of hypersthene and diallage. This analysis agrees very well with those given by G. H. Williams* for the two varieties of websteryte from Baltimore county.

V.

SiO_2	53.21	MgO	20.78
TiO_2	.26	K_2O	.07
ZrO_2	trace	Na_2O	.11
Al_2O_3	1.94	Li_2O	trace
V_2O_3	.03 (034)	H_2O below 105° C.	.14
Cr_2O_3	.20	H_2O above 105° C.	.87
Fe_2O_3	1.44	P_2O_5	trace
FeO	7.92	FeS_2†	.03 (02 S)‡
NiO, CoO	.03	CO_2	.10
MnO	.22	Cl	undet.
CaO	13.12	Fl	undet.
SrO	none		100.47
BaO	none	Sp. gr.	3.34

PERIDOTYTE.

This rock forms several small areas within the noryte-gabbro belt and also occurs at one point along the border between this and the serpentine. The largest mass is one and a half miles northeast of Rising Sun, at the Mount Hope church. The area extends in a northeast direction and is less than one-quarter of a mile long. The rock, which outcrops at numerous points, has weathered in such a way that it presents a very rough and pitted surface. Associated with the peridotyte is some pyroxenyte and smaragdite rock. Another area of much altered peridotyte is found one and a half miles northwest of Rising Sun near the Oak Grove schoolhouse. Peridotyte occurs as a dike outcropping along the railroad just below

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*Am. Geol. July, 1890, p. 35.

†Sulphur calculated as FeS_2, but exists as pyrrhotite or other sulphide soluble in HCl.

‡Perhaps mainly pyrrhotite.

[illegible] and is also exposed a mile and a half west of [illegible] near the state line, associated with pyroxenyte. These two rocks are in fact generally closely associated. While the pyroxenytes are at present not very abundant there is every reason for believing that much of the serpentine has been derived from them and hence that at one time they covered much of a [illegible] large area now occupied by the latter rock.

The rocks under discussion are dark brown or almost black and while they are as a rule coarse-grained, they vary widely in structure and appearance. The variety from the Mount Hope church locality exhibits well the peculiar mottled or poikilitic structure. There are large, brightly reflecting cleavage surfaces of pyroxene dotted over with small grains of olivine largely changed to serpentine, and it is these dull spots which give the rock its speckled appearance. Under the microscope the pyroxene extinguishes uniformly over large areas. Another variety from the dike below Conowingo has a porphyritic structure caused by phenocrysts of pyroxene scattered through a groundmass composed of olivine and accessory hypersthene. The groundmass readily changes into serpentine through which are scattered the yet unaltered pyroxenes. Again the rock may have a more or less banded appearance, as in the state line [illegible]. This structure is produced by layers of compact serpentine [illegible] olivine, alternating with other granular layers [illegible] pyroxene and some comparatively fresh olivine.

[illegible] pyroxene constituents of these peridotytes are hypersthene [illegible] diallage. Associated with these is more or less [illegible] occasionally a little feldspar. In one specimen the [illegible] into zoisite. The pyroxene is readily distinguished [illegible] bright cleavage surfaces and reddish-brown [illegible]. The diallage does not differ from that [illegible] the pyroxenytes. In thick sections it has [illegible] the [illegible]. The columnar structure [illegible] and many [illegible] include rounded

[illegible] is represented by hypersthene [illegible] the macropinacoid show in [illegible] and a bisectrix in the field. [illegible] the brachydiagonal axis be[illegible] character of the mineral together with the small optic angle and well marked trichroism indicate beyond any doubt that it is hypersthene and not enstatite or bronzite. The hypersthene sometimes occurs in porphyritic crystals measuring from a quarter to half an inch in length (6 to 13 millimeters). The olivine is as a rule not distinguishable with the unaided eye except where it appears as dull spots on the cleavage surfaces of the pyroxene. It occurs in well rounded grains which have commonly been more or less altered into serpentine. The manner in which this change takes place does not differ from that so often described. The fibres of serpentine are arranged at right angles to the cracks which form a network traversing the olivine in all directions. The alteration is accompanied by the separation of considerable iron.

Feldspar is occasionally present in these rocks in small amount. As already stated, it had in one specimen been altered to zoisite. The only other mineral observed was a little secondary fibrous hornblende. As a rule the pyroxene found in the peridotytes is quite fresh and unchanged. Many of the latter rocks which have undergone considerable alteration into serpentine still contain scattered through their mass good sized crystals of hypersthene or diallage, which show bright cleavage surfaces. The porphyritic structure of the peridotyte appears to be the exception rather than the rule in this area, whereas in the Baltimore region Williams states that all the olivine rocks exhibit this structure.*

Two distinct types of peridotyte appear in northeastern Maryland, namely, a diallage-olivine rock or wehrlyte, and a hypersthene-olivine rock or harzburgyte (saxonyte). The former usually contains a little accessory hypersthene and the latter may carry diallage in small amount. The two types thus merge into each other and no sharp line of separation can be drawn between them.

The harzburgyte appears to be exceptional in containing hypersthene instead of enstatite or bronzite, which are the orthorhombic pyroxenes commonly present in this type. A peridotyte of this kind with some hornblende and biotite is described by Cross as occurring in Cottonwood gulch, Custer county, Colorado.† The hypersthene was only slightly pleochroic and was rather poor in iron. So far as known this is the only occurrence outside of Maryland of the olivine-hypersthene rock.

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*Bul. U. S. Geol. Surv., No. 28, p. 50, 1886, and Amer. Geol., July, 1890, p. 28.

†Proc. Colorado Scientific Society, 1887, p. 228.

It has already been stated that these peridotytes alter very readily into serpentine and many of them have undergone a more or less complete change into that rock. They doubtless represent the original type whence were derived the various serpentine masses of the region. There is good reason to believe, however, that some of the serpentine has been formed from the pyroxenytes.

SERPENTINE.

The main portion of the serpentine area lies north of the Maryland line in Chester and Lancaster counties, Pennsylvania. It is known as the "State Line serpentine" and forms a belt with a length east of the Susquehanna river of about seventeen miles and an average width of one mile. It also extends across the river into Harford county, where it has a length of sixteen miles and a maximum width of two miles. The southern boundary of the area follows the Mason and Dixon line closely as far west as Octoraro creek where it crosses over into Maryland and extends in a southwesterly direction to the Susquehanna and beyond. Besides this main mass there is a small area west of Conowingo creek, forming an extension of a larger belt in Lancaster county. There is also a small outcrop of serpentine, representing a dike, along the railroad just south of Conowingo.

A study of these rocks, especially in their less altered condition, reveals the presence of two varieties. The first contains crystals of pyroxene imbedded in a compact and quite pure serpentine. Where the change is not yet complete some of the original olivine can still be seen. This type has plainly been derived from the peridotyte.

The second variety has its origin from the pyroxenytes. It is possible to trace this change through its different stages from the fresh pyroxene rock to the final serpentine product. The hypersthene and diallage first alter into fibrous hornblende, the change commonly beginning on the outside of the different individual grains and extending inward, usually along cracks if these are present. This process goes on until no trace of the original pyroxene is left and a rock is produced consisting wholly of secondary hornblende. This transformation may go no further and we will have left the smaragditic and gray hornblendic rocks found so abundantly throughout the region in association with the non-feldspathic rocks. But the alteration does not always stop here, for these amphibole rocks may themselves pass over into serpentine. This change was clearly exhibited in a large boulder found near Sylmar. Even in the hand specimen this was seen to be composed partly of gray, fibrous hornblende, and partly of compact green serpentine, the former mineral graduating insensibly into the latter. Under the microscope the secondary hornblende, with its rather high interference colors and resemblance in all respects to that so often observed surrounding the pyroxene, was seen to be associated with a fibrous aggregate of serpentine. The latter did not have the appearance so characteristic of this mineral when it is derived from olivine, but resembled the variety produced from hornblende. The fibrous aggregates of serpentine seldom have any regular arrangement, but form a confused mass traversing the hornblende substance, from which they can be distinguished by their low interference colors of pale blue and gray. Occasionally the fibres or columns of hornblende are seen separated by the serpentine into which they merge along their borders. It is apparent that in this instance the serpentine is not derived directly from the pyroxenyte, but that this is changed first into fibrous hornblende and the latter subsequently alters into serpentine.

A similar transformation has been described by F. D. Chester as occurring in the extension of this same belt of rocks in Chester county, Pennsylvania.*

Many examples might be cited of serpentines formed from peridotytes, and in fact the latter are regarded as the chief source whence these rocks have been derived. On the other hand, it is comparatively rare to find cases where the serpentine has undoubtedly come from pure pyroxene rocks, as is the case with some of those in northeastern Maryland and adjoining portions of Pennsylvania. Chester† found that many of the state line serpentines have been derived from pyroxenyte, which often contains a little olivine. Ransome‡ describes a serpentine from Angel island in San Francisco bay, which has originated from a rock composed wholly or mainly of diallage. In this instance the alteration seems to have been directly to serpentine and not through the intermediate hornblende stage. Other examples of serpentine derived from pyroxenyte rocks are mentioned by Drasche* from the Tyrol and Ireland; by Bergwerth† in serpentines near Rosignano and Castellina Marittima, south of Pisa, Italy, and by several other writers.

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*Penn. Geol. Surv. Ann. Rept., 1887, p. 104.

†Penn Geol. Surv., Ann. Rept., 1887, pp. 102-105. 1889.

‡Bul. Dept. Geol. Univ. of Cal. Vol. I, p. 222, 1894.

The following analysis (VI) of a deep green, translucent variety of serpentine from the old Broad Creek quarry in northeastern Harford county was made some years ago by F. A. Genth of the University of Pennsylvania.‡

VI.

SiO_2	40.06	MgO	39.02
Al_2O_3	1.37	H_2O	12.10
Cr_2O_3	0.20	Fe_3O_4	3.02
NiO	0.71		
FeO	3.43		100.00
[illegible]	0.09	Specific gravity	2.[illegible]

VEINS AND DIKES.

The basic and ultra-basic rocks of northeastern Maryland are cut by numerous pegmatyte dikes and quartz veins. In addition to these there is the diabase dike already mentioned. The latter extends in a southwest direction through southeastern Pennsylvania and into Maryland, probably crossing the line in the [illegible] of Sylmar. Blocks of diabase were found at various points south of the railroad between the latter town and Rising Sun, and though no outcrops were observed the boulders were in general distributed along a line having the same course as the dike where it was traced farther north. Grimsley states that south of Liberty Grove a diabase dike was traced for nearly a mile, and it is probable that this is part of the same [illegible] Lewis gives the age as late Triassic or early Jurassic, since in Pennsylvania it cuts through shales of the former age and must, therefore, have been formed at the end of [illegible] or the beginning of the next.

[illegible] south of Conowingo and occurring also [illegible] dikes of peridotyte and pyroxenyte. One of these can be seen at the section house just below the town, while not over twenty feet north of it there is a dike of pegmatyte. The peridotyte has been partially changed to serpentine.

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* [illegible] 1871.

† [illegible] 1876.

‡ [illegible] Md. "Verde Antique" Marble and other Minerals [illegible] Iron Co., in Harford County, Md., by Prof. [illegible] 1877.

A noticeable feature of this region is the abundance of white vein quartz, fragments of which strew the fields in many places or are seen mingled with the gabbro and noryte boulders collected in the stone walls everywhere so common in the area. At some points these quartz fragments are so numerous as to form no inconsiderable proportion of the boulders. For the source of this material we must doubtless look to the veins of quartz which have cut not only the basic rocks but also the gneisses bordering upon these to the east and south. The number and extent of these veins is partially indicated by the many fragments derived from them.

The quartz veins have in all probability been formed by lateral secretion, the silica having been leached out of the surrounding rocks and deposited by percolating waters in fissures and crevices produced by orographic movements. Wherever the rocks are well exposed, as along the Susquehanna, they are seen to be traversed by gashes and cracks which have been filled with this secondary quartz, the latter often forming small lens-shaped masses.

The pegmatyte veins* are of special interest and importance since they supply large quantities of feldspar and quartz ("flint") to the potteries of Maryland, New Jersey and Delaware. These dikes, which are often of considerable extent, are found cutting not only the norytes and gabbros but also the serpentines. They have a northeast-southwest direction, corresponding to the strike of the schists and the foliation of the massive rocks where the latter has been developed by pressure. Two of these coarse granitic veins are well exposed along the Susquehanna, one below and another above Conowingo. The former appears less than one-quarter of a mile south of the station, where it is well exposed along the railroad. This dike, which has a width of eight feet, is composed of granite with seams of coarse pegmatyte and is bordered on either side by a saussurite gabbro. The vein a short distance above the town is much more extensive, having a width of three hundred feet or more. In some parts it is made up largely of quartz. The rock is usually a rather fine-grained granite traversed by numerous veins of pegmatyte. Here and there the muscovite forms sheaf-like aggregates, or it may occur in well developed hexagonal plates. The peculiar intergrowth of the quartz and feldspar, giving rise to graphic granite, was also found in this locality. Good sized crystals of tourmaline are occasionally present. Neither of these dikes could be traced very far back from the river.

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*All the acid dikes or veins of this region are here referred to as pegmatyte since they are formed largely of very coarse granite. While they are not infrequently composed of true granite, into which the pegmatite passes, it is convenient to have a general term which shall include all those dikes composed of quartz-feldspar rock.

Three large pegmatyte veins appear along Octoraro creek between the paper mill and the state line. On the hill just above the mill one of these has been worked as a quarry and furnishes a good quality of building stone. Most of the rock at this point is a medium fine-grained granite composed of quartz, microcline, muscovite, and some biotite. The vein has a width of ninety feet and is in places pegmatitic. The second is about three-quarters of a mile above the mill and the third, which is one hundred feet wide, occurs close to the Maryland line. The last is of special interest, since it was found to contain many fragments of the country rock, often of considerable size and not infrequently three feet in diameter. They are composed of much altered and saussuritized gabbro resembling that occurring in the vicinity. In fact, this saussuritized gabbro seems, in many cases at least, to be closely associated with the pegmatyte veins, and it is possible that these have had something to do in producing the alteration of the original rock.

The pegmatytes are composed of white or pink microcline, quartz, muscovite, a little albite and occasionally biotite. Tourmaline is a somewhat rare constituent.

That the pegmatytes are of eruptive origin can scarcely be doubted. The best evidence of this is furnished by the fragments of the country rock found included in these veins. These must have been torn from the side walls as the molten magma was intruded into the fissures. The composition of these coarse granites, differing so widely from that of the norytes and serpentines in which they occur, is also an indication that they are intrusive or have at least not been formed by circulating waters deriving their materials from the surrounding rocks. They are rich in alkalies and do not appear to be affected in their composition by the nature of the enclosing mass.

RELATIONS OF THE DIFFERENT ROCK TYPES.

Having considered somewhat in detail the different rock types represented in the area it remains to discuss the relations existing between them. It has been shown that they are more or less closely associated in their geological occurrence and that many of the types are connected by intermediate varieties. The rocks grow successively more and more basic from the south toward the north. If one starts from Rowlandsville or from a point one mile north of Colora and travels north to the Pennsylvania line he passes over in succession biotite-granite, quartz-mica-hornblende-dioryte (tonalyte), dioryte and quartz-dioryte, hypersthene-gabbro and noryte and serpentine. The distance traversed in thus passing from the acid to the basic and ultra-basic types is sometimes two miles and never exceeds three miles.

GEOLOGICAL RELATIONS OF THE DIORYTES AND GRANITES.

The close relationship existing between the dioryte and granite is evident both from their association in the field and from the study of a large number of sections made from specimens collected at many points in the intermediate zone. As already stated, the diorytes form a belt varying in width from one to one and a half miles, bordering the granite on the north and lying between thatand the gabbro. It was everywhere found impossible in the field to draw any sharp line of separation between the granites and diorytes, and along quite a well defined intermediate belt there is a gradual passage from one to the other. This transition is even more apparent from the microscopical study of a large number of thin sections which show a change in the mineralogical composition of the rocks. It has already been stated that there are two well marked varieties of the dioryte, one a quartz-mica-hornblende-dioryte or tonalyte and the other a quartz-dioryte. The former, which is very granitic in appearance, is confined almost entirely to the southern portion of the area next to the granite, and forms a connecting type between that rock and the quartz-dioryte, while the latter is found along the northern border. By an increase in the amount of hornblende and a corresponding decrease in the biotite, the tonalyte passes into a quartz-dioryte. On the other hand, by a decrease in the amount of hornblende and a corresponding increase in the biotite it passes over into the biotite-granite of the Rowlandsville area. This latter rock, as shown on a later page, is chemically very closely related to the diorytes and can in fact be considered as a biotite-dioryte. These intermediate varieties between the granites and the true diorytes are of common occurrence and cover considerable territory.

There is also a change in the feldspar as the rock becomes poorer in silica and richer in hornblende. In the biotite-granite the feldspar is oligoclase along with a little orthoclase; in the tonalyte it is an acid labradorite, while in the true diorytes this constituent is represented by an acid bytownite. Nowhere was any line of contact observed between the granites and diorytes, and careful search failed to reveal the presence of any eruptive contact, such as that described by Grimsley along Octoraro creek in the vicinity of Porter Bridge. The granite does contain, it is true, the dark, fine-grained, granitic segregations such as those mentioned by that writer. But no reason was found for regarding some of these more basic patches as segregations and some as inclusions. Nor did these change in appearance or composition as the dioryte border is approached, and no increase in their number or size was observed in that direction. In the absence of any better evidence of an eruptive contact than is afforded by these basic segregations, which do not resemble inclusions of dioryte or gabbro, there would seem to be slight ground for supposing there is here any such contact. Careful search failed to reveal the presence of any dikes or apophyses of either rock.

GEOLOGICAL RELATIONS OF THE DIORYTES, GABBROS AND NORYTES.

Bordering the diorytes on the north and closely associated with them are the norytes and hypersthene-gabbros. It was found possible to distinguish two kinds of hornblende-feldspar rocks, one original and commonly carrying considerable quartz, the other secondary and produced by the alteration of the gabbro. In the latter (metagabbro or gabbro-dioryte), quartz was usually absent or present only in small amount, the hornblende more or less fibrous, sometimes nearly colorless in transmitted light, and derived from the pyroxenes. These metagabbros have not been extensively developed in this region and are much less abundant than the true dioryte. As a rule the original hornblende rocks differ in texture from the pyroxene rocks, the former being considerably coarser and resembling the granites in size of grain.

The norytes make up the larger part of the area occupied by the pyroxene rocks. They are abundant not only in Cecil county, but also across the Susquehanna in Harford county, where they are found at many points. The hypersthene-gabbro is probably a facies of the noryte and the two types merge into each other wherever they occur. But though the pyroxene and hornblende rocks are so intimately associated in their geological occurrence, no intermediate varieties connecting the two were found in Cecil county, such as exist between the diorytes and granites. An original hornblende gabbro is stated by G. H. Williams[*] to occur in Harford county, and is said to pass into augite or hypersthene-dioryte, but no such intermediate types were observed east of the Susquehanna.

GEOLOGICAL RELATIONS OF THE NORYTES AND GABBROS TO THE ULTRA-BASIC ROCKS.

The non-feldspathic rocks occur as lens-shaped masses and as dikes within the noryte and are also found along the border next to the serpentine, where they seem to represent a more basic facies of the noryte. The peridotyte and pyroxenyte are closely associated in their geological occurrence and the one type sometimes graduates into the other. This relationship is well shown in the railroad cut just below Conowingo where both of the ultra-basic rocks are found together in the same dike. The olivine is sometimes confined to particular portions of the rock, occurring abundantly in certain layers or bands and being almost absent from others. There results from this arrangement a banded rock made up of alternating layers of nearly black serpentine and of little altered pyroxene—a structure mentioned by Williams in the peridotytes of Baltimore county.[†]

The pyroxenytes are intimately related to the norytes with which they are connected by intermediate types. All varieties are found between those pyroxene rocks rich in feldspar, the latter mineral forming over one-half of the mass, and those without a trace of that constituent. A common type is one containing less than one-quarter of its bulk of plagioclase, the rest being formed of hypersthene.

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[*] Johns Hopkins Univ. Circulars, No. 65, Vol. VII, 1888, p. 62.

[†] Bull. U. S. Geol. Surv., No. 28, 1886, p. 57.

The mode of occurrence of the non-feldspathic rocks indicates that they are younger than both noryte and gabbro. The peridotyte area near Mount Hope church, for example, is plainly an intrusive mass in the older noryte rock, and their more recent age is even more apparent in the case of the dikes.

It has been shown that the serpentine undoubtedly originated from the alteration of the peridotytes and pyroxenytes so closely associated with it. The gradual passage of the latter into serpentine is well exhibited in many of the less altered specimens, where all stages of the change can be traced. These ultra-basic types must therefore have occupied at one time a much larger area than at present and covered the district now composed of serpentine.

A somewhat different alteration product of the pyroxenytes, and one which has perhaps resulted more frequently from their transformation, is an amphibole rock. This is composed of a fibrous hornblende, sometimes green in color (smaragdite), sometimes gray. The different individuals occasionally have a core of unaltered pyroxene, which indicates that the mass was originally composed of this mineral. These secondary amphibole rocks are abundant throughout the area, but appear to be especially common near the serpentine border where, as already stated, the pyroxenytes often occur.

CHEMICAL RELATIONS OF THE ROCKS OF THE SERIES.

The chemical relations of the rocks of the district are shown in the following table in which the analyses are arranged in the order of diminishing acidity.

	I.	II.	III.	IV.	V.	VI.	VII.	VIII.
SiO_2	73.69	66.68	58.57	55.16	44.04	48.02	53.21	40.06
TiO_2	....	0.50	1.41	0.64	2.24	0.23	0.26	....
ZrO_2	....	....	0.09	0.02	0.10	none	trace	....
Al_2O_3	12.89	14.93	16.10	17.51	20.01	20.01	1.94	1.37
V_2O_3	....	....	0.02	0.04	0.05	0.02	0.03	....
Cr_2O_3	....	....	none	trace	none	0.03	0.20	0.20
Fe_2O_3	1.02	1.58	2.89	2.62	4.22	1.13	1.44	....

FeO	2.58	3.24	6.12	5.83	8.61	7.29	7.92	3.43
NiO, CoO	....	....	none	0.01	0.01	0.01	0.03	0.71
MnO	....	0.10	0.18	0.15	0.28	0.18	0.22	0.09
CaO	3.74	4.89	7.39	8.50	11.68	11.42	13.12	....
SrO	....	trace	trace	trace	none	none	none	....
BaO	....	0.08	trace	trace	none	none	none	....
MgO	0.50	2.19	2.33	4.35	5.01	10.05	20.78	39.02
K_2O	1.48	2.05	1.01	1.08	0.15	0.05	0.07	....
Na_2O	2.81	2.65	2.11	1.83	1.24	0.51	0.11	....
Li_2O	....	trace	trace	trace	trace	trace	trace	....
H_2O below 105° C.	1.06	0.16	0.21	0.18	0.11	0.10	0.14	12.10
H_2O above 105° C.	....	1.09	1.27	2.01	1.90	0.57	0.87	
P_2O_5	....	0.10	0.37	0.21	0.52	trace	trace	....
FeS_2	....	....	trace	0.03	0.25	0.11	0.03	....
CO_2	....	....	none	none	none	0.25	0.10	....
Cl	....	....	undet.	undet.	undet.	undet.	undet.	....
Fl	....	....	undet.	undet.	undet.	undet.	undet.	Fe_3O_4 3.02
	99.74	100.32	100.07	100.17	100.42	99.98	100.47	100.00
Sp. gr.	....	....	2.89	2.90	3.03	2.98	3.34	2.66

I. Granite from the Port Deposit quarries.
II. Biotite-granite from the railroad cut at Rowlandsville.
III. Quartz-mica-hornblende-dioryte. Near the foundry on Stone run.
IV. A more basic variety of the same. Porter Bridge on Octoraro creek.
V. Hornblende-dioryte poor in quartz. Three-quarters of a mile northwest of Rising Sun.
VI. Noryte. One mile west of Oak Grove schoolhouse.
VII. Websteryte. Oakwood.
VIII. Serpentine. Broad creek quarry in northeastern Harford county.

Analyses I and II are taken from G. P. Grimsley's paper on the granites of Cecil county.* I. was made by Mr. William Bromwell in the chemical laboratory of the Johns Hopkins University; II.-VII. were made by W. F. Hillebrand, of the United States Geological Survey, and VII. is by F. A. Genth.

It will be observed that the rocks of the series range in composition from that of a granite to a pyroxenyte and serpentine. A comparison of these analyses shows that as the silica decreases there is an increase in the magnesia, the latter constituent being especially characteristic for rocks of this character. The alumina increases from the most acid member of the series to the websteryte when it drops suddenly from [illegible] per cent to [illegible]94. With diminishing silica there is also a decrease in the alkalies, but a decided increase in the lime. The presence of vanadium in these rocks is worthy of notice. Number I. which is given by Grimsley as an analysis of a biotite-granite corresponds very closely with the analyses of quartz-mica-dioryte and of tonalyte as given by Rosenbusch.* Its rather low silica content, its high percentage of lime (4.9) and relatively low percentage of potash (2.05), together with a large amount of magnesia, all seem to indicate a relationship with the diorytes rather than the granites. From the point of view of its chemical composition it should probably be considered a quartz-mica-dioryte rather than a granityte. But what is of special interest in the present discussion is the fact that this rock lies on the border between the diorytes and granites.

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*Jour. Cincinnati Soc. Nat. Hist., Vol. 17, pp. 59-67; 78-114. Cincinnati, 1894.

It will be seen from analyses III., IV. and V., that there are two types of dioryte, a more acid quartz-mica-hornblende-dioryte and a basic hornblende-diorvte. The former is poorer in silica than the typical tonalyte, though it agrees with the latter in mineralogical composition. The hornblende dioryte of number V. contains only a small amount of quartz and is somewhat more basic than much of the true dioryte of the area, which is rich in quartz. It will be observed that the tonalytes (III., IV.) approach the granite in composition, while the analysis of the dioryte proper (V.) corresponds quite closely with that of the noryte (VI.), the only essential difference between the two being in the magnesia.

If the basic eruptives of northeastern Maryland are compared with those occurring in the vicinity of Baltimore on the one side, and with those of Wilmington, Delaware, on the other, certain resemblances and differences are at once apparent. The area under discussion, occupying as it does an intermediate position between the two, might be expected to exhibit certain features common to both. Perhaps the most marked characteristic of the rocks of all three areas is the abundance of hypersthene present. This is especially true in northeastern Maryland and Delaware, where this constituent plays a more important role than the diallage, the latter being present only in small amount. In both the Baltimore and Cecil-Harford areas peridotytes and pyroxenytes are found associated with the gabbros and norytes, where they have by their alteration produced extensive masses of serpentine.

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*Elemente der Gesteinslehre. 1898. p. 140.

In both the Delaware and Cecil-Harford areas the basic rocks are often rich in quartz. But in the former state this is found in the gabbros, while in Maryland it is the diorytes that carry the quartz, the latter mineral being almost absent from the norytes and gabbros. It has been found at only two points, namely, in the vicinity of Mount Hope, Baltimore county, and the junction of Stone run and Octoraro creek. Brown hornblende occurs as an accessory constituent in the other areas, but was not observed in any of the rocks under discussion. Olivine is equally rare in all three districts. Biotite is found in the gabbros near Wilmington but is lacking in the Maryland rocks.

The area under discussion differs in certain respects from those lying to the east and west of it. One distinguishing feature is the abundance of dioryte, usually rich in quartz, and its passage into the granites. Another is the comparatively slight development of gabbro-dioryte from the gabbro, an alteration which has taken place on a large scale in the other two areas. Though many of the gabbros and norytes show the early stages of this change, those rocks are comparatively rare in which the pyroxene has been completely altered to hornblende. This does not include the saussurite gabbros which have had both their original constituents changed into secondary products. A third difference is the presence in this area of many large granite and pegmatyte dikes in the noryte and serpentine Some large blocks of pegmatyte were found at one point in the Baltimore area* but this was the only instance of such an occurrence within the basic eruptives of that district.

RÉSUMÉ AND GENERAL CONCLUSIONS.

In northeastern Maryland a series of acid and basic eruptive rocks has broken through the ancient gneisses (pre-Cambrian?). The following types are represented: biotite-granite, dioryte, quartz-dioryte, quartz-mica-hornblende-dioryte (tonalyte), noryte, hypersthene-gabbro, pyroxenyte, peridotyte, and serpentine. The basic and ultra-basic varieties have been cut by extensive dikes of granite and pegmatyte which have a northeast-southwest direction and have no apparent connection with the granite mass to the south. Near the eastern end of the main belt there is a Triassic diabase dike which has been traced for a distance of seventy miles through southeastern Pennsylvania and Maryland.

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*Bul. U. S. Geol. Survey, No. 28, 1886, p. 25.

Where the granites border the area of basic eruptives on the south there is a gradual passage of the granite into dioryte and no line of separation can be drawn between them. The noryte forms the bulk of the main mass of basic rocks and the hypersthene-gabbro is to be regarded as a facies of the noryte. The latter rock is in some places found to graduate by intermediate types into pyroxenyte and the two occur intimately associated in the field. The pyroxenytes and peridotytes are closely related and they commonly occur together, in one instance both being found in the same dike.

A study of their geological relations and occurrence makes it evident that the rocks of this area were not all formed at the same time. It is probable that the region was the scene of eruptive activity for a considerable period, during which the different types were produced. The norytes and gabbros appear to have been the first to be erupted. The diorytes were probably formed at the same or nearly the same time. The absence, in Cecil county, of intermediate types between the pyroxene and hornblende rocks may indicate that they are of different ages, and it is not unlikely that the formation of the dioryte followed shortly after that of the norytes and gabbros. Together these three types compose the long narrow belt of basic rocks that have broken through the ancient gneisses.

It is difficult to give with any degree of certainty the relative age of the granites since the requisite data for the determination of this are wanting. It seems probable, however, that they are younger than the norytes and diorytes. The presence of the numerous granite and pegmatyte dikes in the basic rocks may indicate that the granites of the main mass lying to the south are younger, though no connection between these dikes and the larger granite area was observed. The gradation of the granite into dioryte and the absence of an line of separation between them is thought to be evidence that their difference of age is not very great.

The peridotytes and pyroxenytes were erupted at a later period than the norytes and gabbros through which they have broken. Some of the pyroxenytes, however, apparently form peripheral facies of the noryte and probably belong to the same age as the latter. The pegmatytes are more recent than the basic rocks and serpentines and since the latter have originated from non-feldspathic types the acid dikes are also younger than most of the peridotyte and pyroxenyte. The last rock to be erupted was probably the diabase composing the dike which cuts the noryte-gabbro mass, and was formed in late Triassic or early Jurassic time.

The northeastern Maryland area taken as a whole seems to furnish an example of the occurrence of several rock types which represent the facies of a single magma and unite to form a geological unit. This view does not necessitate the supposition that all the rocks were formed either at the same time or by a continuous eruption, but there may have been several periods of activity during which different types were produced, and as already stated, this was doubtless the case in this district.

PLATE XVI.

Fig. 1.—Dioryte.

From one mile northeast of Rising Sun. Section No. 71. Magnified 20 diameters. Ordinary light. The hornblende occurs mostly in lath-shaped individuals which form clusters scattered through the feldspar. Considerable magnetite is also present.

Fig. 2.—Quartz-Mica-Hornblende-Dioryte (tonalyte).

From one-half mile west of Porter Bridge. Section No. 260. Magnified 20 diameters. Ordinary light. A good sized biotite individual shows near the center of the field and hornblende is seen near the edge. The feldspar is largely altered to epidote, which forms irregular crystal aggregates. The clear white mineral is quartz.

PLATE XVII.

Fig. 1.—Noryte.

From one mile west of Oak Grove schoolhouse. Section No. 237. Magnified 20 diameters. Ordinary light. The white feldspar is not as cloudy as in many sections. The light colored mineral is hypersthene and the black is magnetite.

Fig. 2.—Noryte poor in feldspar.

From cross-roads three-quarters of a mile south of Rock Springs. Section No. 104. Magnified 20 diameters. Ordinary light.

This rock is composed largely of hypersthene with only a little feldspar. It is a common type and is intermediate between the noryte and pyroxenyte.

PLATE XVIII.

Fig. 1.—Peridotyte (wehrlyte).

From near the point where the west branch of Stone run crosses the state line. Section No. 43. Magnified 20 diameters. Ordinary light. The olivine is partially altered to serpentine. The diallage exhibits its characteristic columnar structure and its black inclusions. The olivine is confined chiefly to certain bonds or layers, one of which shows on the side of the figure. This mineral also occurs included in the diallage.

Fig. 2.—Pyroxenyte (hypersthenyte).

From Oakwood. Section No. 159. Magnified 20 diameters. Nicols partially crossed (made 55° angle with crossed position).

This rock is composed entirely of hypersthene. Eight or ten different individuals are shown in the figure.

PLATE XIX.

Fig. 1.—Saussurite gabbro.

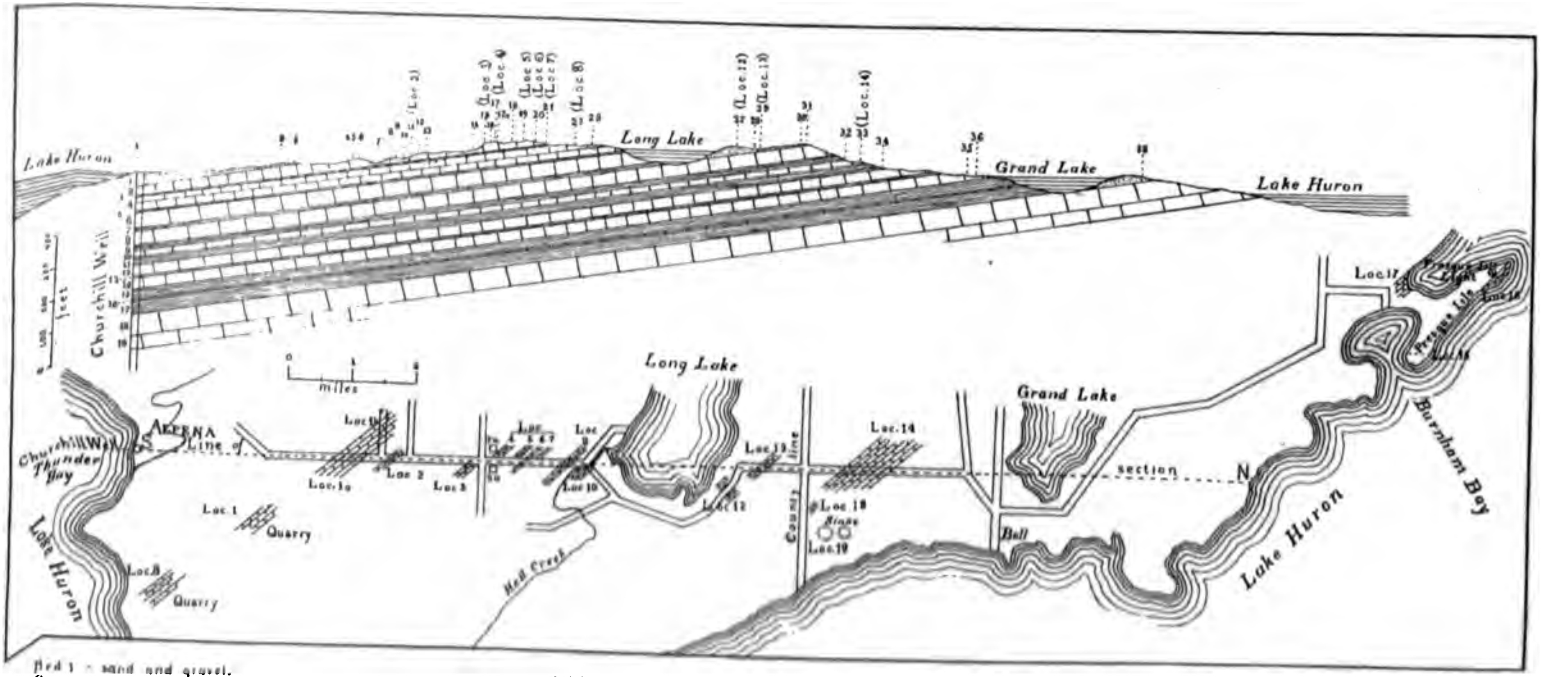
From Octoraro creek just below the state line. Section No. 120. Magnified 30 diameters. Ordinary light.

This rock is a typical saussurite gabbro composed of fibrous, green, secondary hornblende (smaragdite), and white, opaque saussurite. The latter is made up almost entirely of zoisite. One good sized columnar crystal of this mineral is shown, bordered on either side by smaller individuals of the same.

Fig. 2.—Quartz-dioryte with epidotized feldspar.

From one-quarter of a mile below Porter Bridge on Octoraro creek. Section No. 266. Magnified 30 diameters. Ordinary light. The feldspar is replaced by aggregates composed of minute crystals of epidote. The dark, granular patches which appear scattered through the clear white quartz, and which mark the outlines of the feldspar crystals, are epidote. Several hornblende individuals show on the edge of the field.

PLATE XX.



Bed 1 = sand and gravel.
Bed 3 · thin shale bed
Bed 5 · "
Bed 13 · " "
Bed 16 · thin limestone bed

GEOLOGICAL SECTION AT THUNDER BAY, MICHIGAN.

A PRELIMINARY GEOLOGIC SECTION IN ALPENA AND PRESQUE ISLE COUNTIES, MICHIGAN.[*]

By Amadeus W. Grabau, Troy, N. Y.

PLATE XX.

INTRODUCTION.

The following section was prepared in the late summer of 1900, with the assistance of Mr. W. F. Cooper, of the Michigan geological survey. As no topographical map was available, the profile of the country along the section had to be prepared in the field, at the time the geological data were collected. Distances were measured by means of a cyclometer attached to the bicycle, which was the only conveyance employed in the field. To eliminate errors due to unevenness of the country and to other causes, the cyclometer readings were checked by special readings on the section lines. Elevations were obtained by reading the aneroid barometer at all the stations, as often as these stations were passed, and correcting these readings by the barograph record obtained from a stationary instrument at Alpena. Owing to the length of the section, the barograph corrections did not always prove satisfactory, especially as several severe atmospheric disturbances affected the aneroid in the northern part of the section, which were felt to a less degree at Alpena, where their record was obtained by the barograph.

LOCATION AND EXTENT OF THE SECTION.

The section is located in Alpena and Presque Isle counties, Michigan. It runs north from the city of Alpena along the meridian of 83° 27′ longitude west of Greenwich, and forms the western boundary of the eastern third of range 8 E. It extends through the whole of townships 32 and 33 north and parts of townships 31 and 34 north. The total length of the section is nearly eighteen miles, but the distance covered in its preparation was nearly double that.

The section is interrupted near the middle by Long lake, and it passes by the eastern end of Grand lake. It strikes the shore of lake Huron about four miles southeast of Presque Isle light. About one-half of the line of the section is along a north-south road.

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[*] Published by permission of Dr. A. C. Lane, State Geologist.

TOPOGRAPHY OF THE SECTION.

In the following table the distances between stations as calculated from the cyclometer readings are given. The elevations given are calculated from the aneroid readings and corrected by the barograph readings. The resulting elevations are of the various stations above the mean level of lake Huron, which is taken as 580 feet above the sea.

STATION, NUMBER AND LOCATION.	Distance between points. mi. — yds.	Elevation above Lake Huron. (580 ft. A. T.)
1. Thunder Bay	....	00.0
2. Round House	2.2 — 66	27.7
3. Sec. 15, N. E. Cor	.2 —110	40.7
4. Sec. 10, E. line base of terrace	.8 — 66	44.4
5. Sec. top of terrace	.0 —110	56.4
6. Sec. 10, N. E. Cor	.1 — 22	59.4
7. Sec. 3, E. line, base of terrace	.2 —110	52.1
8. Section top of terrace	.1 — 88	62.1
9. Sec. 3, end road running west	.1 —	67.1
9a. Offset on same, top of terrace	.1 —	79.1
10. Sec. 3, E. line, base of terrace	.1 — 66	62.5
11. Section top of terrace	.1 —	72.8
12. Sec. 3, E. line top terrace	.6 — 88	85.8
13. Sec. 3, N. E. corner, road running west	.19—132	92.8
14. Sec. 34, E. line	.7 — 44	93.5
15. Sec. 35, W. line	.1 —132	103.5
16. Sec. 34, N. E. corner	.0 —154	119.9
17. Sec. 27, E. line top of terrace	.0 — 88	128.9
17a. Sec. 27, outcrop	.0 — 88	128.9
18. Sec. 27, E. line, base of terrace	.1 —154	120.2
19. Section, outcrop	.1 —110	124.2
20. Sec. 26, W. line	.1 —132	134.2
21. Sec. 27, E. line, base of terrace	.2 — 44	124.2
22. Section outcrops	.4 —132	119.2
23. Sec. 22, fork roads	.2 — 88	125.2
24. Sec. 22, centre north line	.7 — 88	117.9
25. Long lake	.8 —110	110.6
24a. Hell creek bridge	.2 — 22	100.6
25a. Sec. 23, north line, center	.5 —132	106.4
26. Road east of Long lake	1.2 —154	121.4
27. Sec. 3, E. line	1.1 — 66	125.2
28. Sec. 3, end road running west	.4 — 00	113.0
29. Sec. 3, E. line	.0 — 88	126.0

STATION, NUMBER AND LOCATION.	Distance between points. mi. — yds.	Elevation above Lake Huron. (580 ft. A. T.
30. Sec. 3, E. line, top of ridge	.6 — 44	136.8
31. Town and county line	.0 — 88	136.8
32. Sec. 34, E. line, top of maraine	.6 — 00	134.8
33. Sec. 35, W. line, Rabiteau's farm	.2 —110	112.6
34. Sec. 27, E. line, base of terrace	.3 — 00	81.6
35. Sec. 22, E. line running west	1.3 — 22	63.4
36. Fork of roads	.1 — 88	76.4
37. Lake Huron at Bell	.1 —132	32.4
38. Grand lake at Lumber mill, Sec. 15, N. E. corner	1.4 —154	56.2
39. Top moraine, Grand lake	3.8 — 00	41.7
40. Grand lake isthmus	.2 — 44	11.7
41. Top gravel ridge, Club house	.1 —132	25.1
42. Kaufman's	.2 — 88	31.1
43. Lake Huron at Presque Isle Light	5.22— 00	33.6

Of the stations here recorded, Nos. 1 to 23, and Nos. 27 to 35, are on the section line; the others are either to the east or the west of the section line. From these data, the accompanying profile of the section (plate xx) has been constructed.

From a careful plotting, it appears that Long lake and Grand lake lie along the outcrops of shale beds of considerable thickness. The valleys of these two lakes, therefore, which extend along the strike of the strata, represent longitudinal lowlands, carved by streams of the subsequent type out of the softer strata.

STRATIGRAPHY OF THE SECTION.

Owing to the extensive drift coverings of this region, rock exposures are comparatively rare, and are confined to roadside cuttings, quarries and the few natural exposures, which are found along the tops of the terraces. From well-records, however, we gain a knowledge of the succession of beds, and of the thickness of the various members. Taking this as the foundation of the stratigraphic work for this region, we may attempt a correlation of those beds which crop out on the surface, with those recorded in the well. Lithic characteristics will have to be relied upon in such a correlation, and for the area covered by this section, these may be considered reliable. This is especially the case, since all the strata entering into the section are off-shore deposits, with a minimum of coarse detritus, and hence of a character which remains uniform over a large area.

The following succession of strata in this region has been derived from the records of the Churchill well, the location of which is near the southern end of the section in Alpena.

The mouth of the well is near the level of lake Huron, and above the coral limestone of Alpena. This rock is the middle member of the Traverse (Hamilton) group of Michigan, and hence the entire upper portion of this group is unrepresented in the well record. At a depth of over 1250 feet, the well ends in the salt beds of the Salina group, having penetrated the entire lower Devonic rocks of the region.

SUCCESSION OF STRATA IN THE CHURCHILL WELL AT ALPENA, MICH.

		FEET
1.	Sand and boulders	41.0
2.	Hard white (light-colored) limestone	25.0
3.	Shale	9.0
4.	Very hard white limestone	49.5
5.	Shale	2.5
6.	Extra hard gray limestone	40.0
7.	Blue shale	20.0
8.	Hard white limestone	34.0
9..	Shale, 7 feet white and slimy, possibly gypsum (?)	18.0
10.	Hard white limestone	23.0
11.	Very sticky blue shale	27.0
12.	Hard white limestone	32.0
13.	Shale	3.0
14.	Hard white limestone, upper ⅔ extra hard	30.0
15.	Shale	24.0
16.	Hard white limestone	5.0
17.	Shale, mostly blue	52.0
18.	Hard white and gray limestone, mostly extra hard	63.0
19.	Extremely hard (flinty) limestone	39.0
20.	Shale	25.0
21.	Hard gray and white limestone	103.0
22.	Shale	20.0
23.	Hard white limestone	86.0
24.	Sandy lime shale	10.0
25.	Hard white limestone	468.0

This carried the drill down into the rock salt of the Salina group.

Strata 15 to 17 are provisionally considered the equivalent of the New York Marcellus, though there is no evidence at present to indicate that the faunal characteristics, on which the separation of the Marcellus beds alone rests, are found in this region. For this reason it is perhaps better to speak of these beds as the lowest Traverse shales, regarding the five-foot stratum of limestone (No. 16) as an integral part of the series. The total thickness of this lowest shale series is therefore 81 feet.

Strata 18 and 19 are provisionally referred to the Dundee limestone, which is considered the equivalent (approximately) of the Onondaga limestone series of New York. The combined thickness of the two strata referred to this formation, is 102 feet.

Stratum 21 probably represents the Mackinaw limestone, a formation which is believed to be the time equivalent of the Manlius limestone of New York. It undoubtedly is of upper Siluric age, but the determination of its exact equivalency must be deferred until paleontological investigations are made.

Whether the shale of stratum 20 belongs to the overlying or underlying formation is likewise an unanswered question.

If the above correlations are correct, the well record gives us the following thicknesses of Devonic formations.

Traverse upper shales	not represented
Traverse middle limestone	25
Traverse lower shales and limestones	378
Total middle and lower Traverse	403
Dundee limestones	102
Total	505

The strike of the strata of this region is approximately northwest and southeast. The dip is 42 feet to the mile toward the southwest. This is equivalent to 30 feet to the mile along the line of the section.

A. Traverse Middle Limestone.

This limestone underlies a considerable area to the north and northeast of Alpena. It appears on the surface in the northeastern portion of the town where several quarries are opened in it (Loc. 1). It is also quarried in the cement works quarry less than a mile east of the town, near the lake shore, or approximately southeast of the preceding locality. This is designated Loc. 9.

The rock first appears on the section line, about a mile north of the town (Sta. 4). It appears at intervals to the north of this, and is prominently exposed in the terrace which crosses the section line in a direct northeast line from the quarries. (Sta. 8).

This terrace continues northwestward and furnished another good exposure of the limestone about a tenth of a mile west of the section along the first west road. (Stat. 9a. Loc. 1b.)

Loc. 1. Quarries northeast of Alpena. The limestone is here almost wholly composed of corals and hydro-corallines, though brachiopods and other organisms are not wanting. The corals are Favosites and Acervularia, the former probably represented by a number of species. Large masses of the rock are entirely made up of these corals, which appear to be still in the place where they grew. Other large masses of the rock are composed of the hydro-coralline Stromatopora and allied genera, which also appear to be represented by several species. Among the smaller corals, species of Zaphrentis, Aulopora, and Ceratopora predominate, while the Bryozoa are chiefly represented by fenestelloids, and Lichenalia-like types. The chief brachiopods are: *Atrypa reticularis*, (an extremely convex form), *Spirifer* cf. *S. mucronatus*, Stropheodonta, several species, *Cyrtina umbonata* var *alpenensis*, *Gypidula romingeri* etc.

The central mass of limestone of this region has all the characteristics of an ancient coral reef in which the chief reef-builders were the Favosites Acervularias, and Stromatoporas. These formed the main mass of the reef, while between them grew the smaller species, and the other organisms which go to make up the *ensemble* of the reef population. A careful examination of sections in the quarries shows that there is an absence of stratification and regularity of structure in general, within the reef portion of this limestone. This is to be expected, since this portion of the mass is entirely of organic origin. In form, this portion is dome-like, and the stratified beds of limestone which flank it, dip away from it in all directions at an angle exceeding that of the normal dip of the strata of this region.

The origin of these limestone masses and the accompanying beds of stratified limestone may be explained as follows:

In the Devonic sea of this region, the luxuriant growth of corals and other lime-secreting organisms produced isolated reefs, which rose to within the sphere of wave activity. Being subject to the continued attack of the waves, these reefs were destroyed wherever the vitality of the polyps was insufficient to resist the wave attack. Wherever exposed, the dead coral rock was ground into a coral sand, this being accomplished in part by the direct activity of the waves, in part by the aid of tools chiefly in the form of loose blocks which were rolled about, and served to grind up the coral rock, and in part by the many reef-destroying organisms, which in every reef are actively breaking up the dead coral masses. The resulting coral sand was carried away by the waves and currents, and deposited on the flanks of the reefs, and in the quieter water beyond.

Stratification is well marked in such a fragmental limestone, or lime-sandstone, and it not infrequently happens that cross-bedding structure, ripplemarks, and other shallow water characteristics are shown in such a limestone. In fact, we may consider that there is no essential difference in structure between such lime-sandstones and ordinary quartz-sandstones, the mineralogical character of the component grains being the only distinction. In such a lime-sandstone fossils need not be abundant, in fact we could understand their total absence. Near the growing reef, which is the source of the coral sand, the minor reef organisms may be expected to occur, but their number would decrease in proportion as we pass away from the reef. In the immediate vicinity of the reef, an interlocking of the organically and the mechanically formed limestones occurs, for at times the coral sand encroaches upon the reef, and again the reef organisms extend outward, growing on the foundation of sedimentary coral sand. This inter-locking of the two types of limestone is well shown in the quarries opened in the reefs in question, and on either side the stratified limestone, consisting wholly of consolidated coral sand, is seen dipping away from the reef. This stratified limestone is strikingly barren of organic remains; only a few brachiopods or small corals being found at intervals. In texture it is very uniform, and in composition very pure, yielding upward of 97% of

$CaCO_3$. Some of the limestone of this type in Petoskey, Mich., and presumably of the same horizon, is reported to yield 100% $CaCO_3$. The purity of these limestones is readily accounted for when we remember that the reef-building organisms flourish only in water free from terrigenous matter. Since the stratified limestone beds which always accompany the reef are derived from the organically formed limestone, and since there is an absence of terrigenous matter within the area of their deposition, it follows that these limestones must be very pure, within a radius of some magnitude from the central coral reef, the source of supply of the lime sand. It furthermore follows that the thickness of the coral reef, and the thickness of the flanking fragmental limestones, may agree and that beds of great thickness may accumulate, depending on the length of time during which the reef remains in an actively growing condition.

It thus appears that the reefs are the most trustworthy guides to the purity of the limestones. Close to the reefs from which they were formed, these limestones will generally be free from foreign material, while this may increase in amount progressively with the distance from the reef.

Loc. 9. Quarry of Alpena Cement Co. This limestone is gray and crystalline, and heavy bedded showing for the most part perfect stratification. The coral reef character is shown in several parts of the quarry, its structure being very similar to the reef of the preceding locality. Large masses of Favosites and Acervularia make up the greater part of the reef, and with these occur large stromatoporoids. Among the associated remains are *Gypidula romingeri, Atrypa reticularis, Spirifer mucronatus, Pterinea flabella* and others.

This reef, though similar to the one of Loc. 1, appears to be entirely distinct from it. The two are, however, connected by sparingly fossiliferous coral sand, which was derived from both, and constitutes the main material of the bedded limestones.

Loc. 1a. The rock exposed here shows essentially the same characteristics as that of the preceding two localities. Favosites appears to be the most common fossil. Other fossils are *Atrypa reticularis, Spirifer granulosus, Zaphrentis* sp. and several species of *Strophcodonta.*

Loc. 1b. The limestone has here less the character of a reef, but appears to have accumulated in the immediate neighborhood of a reef. It is highly fossiliferous, Favosites and Stromatopora being very common, though apparently not forming very large masses as in the reef portions of the preceding localities. Stropheodonta is a well-represented genus, though the species are generally small. *Gypidula romingeri* and *Atrypa reticularis* are among the other common brachiopods.

It has not been ascertained what the actual thickness of the limestone is. In the Churchill well twenty-five feet are shown, but since these are overlain by drift, it is evident that this is merely the minimum thickness and that the actual thickness may be somewhat greater. That it is not very much more is indicated by the nearness of the outcrop of the overlying shales on the south.

Loc. 2. About two miles north of Alpena, at Sta. 11 on the section line, a highly fossiliferous limestone is exposed along the roadside and in the adjoining farm lands. This rock consists mainly of the stems and joints of crinoids, and of various Bryozoa, among which the fenestelloids are the most common. In the exposed portions the fossils appear to form a loosely agglomerate mass, without the interstitial filling of calcareous sand. Brachiopods are very common, and the space between the valves is generally unfilled, except for subsequently infiltrated calcite. The brachidium of these brachiopods is generally well preserved, indicating a freedom from disturbances. *Gypidula romingeri* and *Atrypa reticularis* are both abundant. Stropheodonta cf. *S. demissa* and *S. nacrea* are also common. *Chonetes coronatus* is a conspicuous species, while *Spirifer mucronatus* and *S. granulosus* are among the other characteristic brachipods.

Fenestella, Loculipora, and the other frondose Bryozoa are also well preserved, frequently still showing the original funnel-like form of the frond.

Crinoid stems and joints make up the greater portion of the mass. These are mostly enlarged, and changed to cleavable calcite. Dog-tooth spar is common in the cavities, which latter are very numerous, since all the remains are loosely joined, forming a porous or loose-textured rock.

No Favosites or other corals have been observed. The condition of preservation of these fossils is such as to point to quiet and rather deep water wherein they accumulated, the depth being apparently beyond that of wave activity. This limestone is therefore of great purity, since it consists wholly of the calcareous remains of organisms. The position of the limestone appears to be near the base of the middle Traverse limestone (stratum 2), but its characters are probably not traceable over a very large area.

Loc. 3. About a mile north of this outcrop, at Sta. 15, is another outcrop of limestone along the west line of Sec. 35. Here the limestone has again the coral-reef character, with Acervularia and Favosites predominating. This exposure belongs near the base of the limestone series. Besides the fossils mentioned, Zaphrentis, fenestelloids, *Atrypa reticularis* and crinoid stems may be mentioned.

Loc. 4. This is two-tenths of a mile north of the last locality, at Sta. 17a, along the east line of Sec. 27. The limestone here is similar to the preceding, and belongs to the same series. It contains numerous crinoid remains, and Stropheodonta is the commonest genus of brachiopods.

B. The Lower Traverse Shales and Limestones.

Loc. 5. About a third of a mile further north, at Sta. 19, is an outcrop of impure but highly fossiliferous limestone, which weathers to a yellowish-brown color, and leaves an earthy residuum. The reef corals are rare, but other types, such as Zaphrentis, Aulopora, and the like, are met with. Brachiopods are common and among these a robust variety of *Atrypa reticularis* is the most abundant. Other common species are: *Spirifer mucronatus, Chonetes coronatus, Stropheodonta demissa, S. concava,* and *S. erratica* (?).

From the thin bedded character of this rock, it might well be mistaken for a shale in the drill record. At any rate, this rock underlies the crystalline limestone, and with the beds next below it probably forms the nine-foot stratum of "shale" (stratum No. 3) in the Churchill well record.

Loc. 6. Less than two-tenths of a mile to the north, at Sta. 20, is an outcrop of black shale, highly bituminous, and characterized by the extreme abundance of a small species of Stropheodonta. This is a species closely related to *S. plicata* of the Iowa Hamilton. The plications are angular near the beak, but become rounded and less pronounced toward the front. The exterior of the shell is striate, the interior pustulose. When worn, the shell appears punctate. A few fenestelloids occur, but other fossils are very rare.

Loc. 7. This is at Sta. 21, something more than two-tenths of a mile north of the preceding locality. The rock is a dark-colored, somewhat shaly, fine-grained bituminous limestone, and lies just below the shales of Loc. 6. It is exposed at the base of a terrace, on the west side of the road, and fossils are very rare in the exposed portion.

Loc. 8. This is at Sta. 22, near the forks of the road south of Long lake. The rock is thin-bedded, gray, weathering to buff, and highly fossiliferous. Favosites and Acervularia occur, but not in very large masses. *Atrypa reticularis* is the most abundant brachiopod, being represented by an extremely convex variety. Several species of Stropheodonta occur, among which a variety of *S. demissa,* and *S. erratica,* and *S. inequistriata* should be mentioned. *Cyrtina umbonata alpenensis* also occurs. These limestones are probably a part of the stratum 4 series of the Churchill well.

Loc. 10. This exposure is at Sta. 24, where Hell creek, the outlet of Long lake, cascades over some limestone ledges. This locality is off the section, and the rock here exposed appears to be the correlative of the limestone series No. 6 of the Churchill well. Acervularia and Favosites occur here, and with these *Spirifer granulosus, Sp. mucronatus, Atrypa reticularis,* and Rhipidomella cf. *R. vanuxemi.* This same rock probably crops out close to the lake.

Locs. 11-13. These are small outcrops of limestone along the roadside at Stas. 26, 27 and 29 respectively. They appear to belong to the limestone bed (8) which underlies the blue shale of Long lake (7), and contain Acervularia, Gypidula, and other fossils characteristic of the massive limestones.

Loc. 14. This is at Sta. 33, half way between Long and Grand lakes. The best outcrops are along the roadside and on the farm of Mr. Rabiteau. The rock is thin-bedded and extremely fossiliferous, the fossils weathering out in relief. The limestone is not very pure, an earthy residuum remaining on the solution of the lime. This is by far the most fossiliferous series of beds in the region, the largest number of species in the collection having been obtained from the outcrops of this rock.

Brachiopods predominate, with the large and robust *Atrypa reticularis* at the head. *Gypidula romingeri* Hall and Clarke is also extremely abundant, while the Stropheodontas and Spirifers are common, and represented by all the common and some rare species. Chonetes, Productella, and other characteristic Hamiltonian brachiopods occur abundantly. Among corals the smaller types predominate, i e., Aulopora, Ceratopora etc. In the lower beds, however, the reef-building types occur, notably Acervularia. Stromatoporoids are also, though more rarely met with.

Loc. 15. This is along the shore of Burnham bay, southwest of Presque Isle. No outcrops are found here, but the beach is composed of rounded and subangular dark to light gray limestone pebbles. Chert is a common constituent of this rock, which probably belongs to the Dundee formation (representing the Corniferous limestone).

Loc. 16. This is in front of Presque Isle light, along the shore of lake Huron. A dark, somewhat shaly, apparently non-fossiliferous limestone crops out at the water's edge. This undoubtedly is the lower Dundee limestone (stratum 19) which probably forms the shore for a considerable portion of the county.

Loc. 17. This is on the mainland, north of Presque Isle. The rock, though locally disturbed, chiefly by shore ice, is undoubtedly in place, and represents the stratum overlying that which crops out in front of Presque Isle light. The rock is a very compact and uniform grained limestone, of a drab color, and sparingly fossiliferous. Almost the only fossil found in it was a large and rather smooth Paracyclas.

Loc. 18. This is on the farm land north of the county line and east of the line of the section. The outcrop is in line with those of Loc. 14, and of the same type, containing also the same species of fossils.

Loc. 19. This is at the sink holes north of the Presque Isle county line, and east of the line of the section. The rock exposed in the walls of these sinks is as follows:

	FEET
Fine grained limestone, of a very compact texture................	12
Shale, bituminous at top, but becoming more calcareous downward, with fossils of the Hamilton types......................	—

The thickness of the shale has not been ascertained. The limestone underlies the shaly limestone of Loc. 14, and if the correlation of the latter with the "shale" of stratum 9 is correct, this limestone and underlying shale are to be correlated with strata 10 and 11 of the Churchill well, respectively.

Some of the sink-holes are 50 or more feet in depth, but their sides are difficult to examine, since they are usually perpendicular, or else covered by talus.

Shales with fossils of the Marcellus type are said to be exposed in the vicinity of Bell, but they have not been seen. A fragment, however, containing a characteristic Marcellus Chonetes, and obtained from this exposure, has been seen. The location is along the strike of the shales out of which Grand lake is carved.

Rensselaer Polytechnic Institute, May, 1901.

EDITORIAL COMMENT.

THE ARCHEAN OF THE ALPS.*

The very able and interesting volume by Duparc and Mrazec, which has lately come to our notice, is a valuable contribution to the geology not only of the Alps, but of the Archean of every country so fortunate as to have any Archean rocks. The investigation was carried through seven years. It may, therefore, be presumed that the results reached are the best that can be attained by the intelligent use of all methods of modern geological research. Careful and extended fieldwork was supplemented by chemical and petrographical laboratory study.

The monograph abstracts the opinions of former geologists as to the nature and relations of the Mont Blanc massif, but carries the examination into greater detail than any predecessor, reaching, therefore, somewhat different conclusions. It is specially detailed and complete on the relations of the granite (called protogine, a term which the authors would discard) to the schists, and throughout all its descriptions it is illustrated by half-tone reproductions of photographs of Alpine scenes.

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*Recherches géologiques et pétrographiques sur le massif du Mont-Blanc. Par Louis Duparc et Ludovic Mrazec. 24 plates. pp. 228, quarto, Geneva. 1898. (Mem. Soc. Phys. et Hist. Nat., Tome xxxiii, No. 1)

French and Italian geologists have differed on the question of the nature and origin of the rock of the massif of Mont Blanc, some regarding it as an integral part of the schists, but more gneissic, and some as an eruptive rock independent of the schists. The authors, however, share with Michel Lévy the opinion that it is an igneous rock intrusive into the schists, but they lay special stress on the metamorphism of the schists, developed by the granite, and the endomorphism of the granite produced by the schists.

The authors accept two rocks, viz: the granite and the schists, as independent, unallied facts. They trace out their lines of contact and map their separate areas. They make petrographical and chemical examinations of these two end terms, all tending to demonstrate and emphasize the contrasts that separate them in the field and in the laboratory. Then they gather together the points of alliance. They find there are four terms in the series instead of two terms and that from one extreme to the other there is a gradual passage, thus, (1) schist, (2) schistose granite, (3) gneissic granite, (4) granite. This gradual succession is found not only once, and twice, but in many instances. It is an important point in the genetic study of the igneous rocks to find this fact so well established by those able investigators, for it has been sometimes affirmed that there is no such transition between the schists and the granites, and can be none. Reference may be made to page 23 where the phenomena about the Mer de Glace and the Grande Becca are described. This result is identical with that recently reached in the investigation of the Archean crystalline rocks of Minnesota. This gradation from schist to granite, which reasonably interpreted in Minnesota as an indication of an original alliance of the two extremes, through the means, in one origin, is differently viewed by Messrs. Duparc and Mrazec. and the rocks at the extremes of the series are considered as separate in origin and in date. They detail at considerable length the structural relations of the granite with the schists (mica schists) finding it frequently eruptive into the schists.

Owing to the stratified condition of the protogine Favre considered it a granitoid gneiss older than the mica schists which envelop it. Lory like Favre ranked the protogine amongst the crystalline rocks but younger than the mica schists.

He reached the conclusion that the massif of Mt. Blanc forms a synclinal pinched between two faults, but later in consequence of an excursion with Michel Lévy he recognized the eruptive nature of this rock. The Italian geologists, with Zaccagna at the head, consider it also as a particular facies of primitive gneiss. Amongst them this opinion is strongly rooted, for in 1893, in his "Geology of the province of Turin," Baretti uniformly considers the protogine as a lower term of the crystalline rocks. With Gerlach the protogine of Mt. Blanc is manifestly an eruptive rock. Its apparent stratification is a result of compression. Michel Lévy shares the opinion of Gerlach, as to the eruptive and intrusive nature of this rock. He chiefly bases his argument on the contacts of the rock with its crystalline mantle, and also upon the phenomena of injection and of metamorphism which it develops there. The authors themselves, in their earlier papers, have started from the same point of view and have insisted chiefly on the metamorphism in question. It can be stated, in general therefore, that, with the exception of the Italian geologists, there seems to be at present an approach to agreement on the eruptive nature of the protogine of Mt. Blanc.

But having agreed that it is an eruptive those who have studied this protogine seem not to have accounted for its origin, nor for the terms that intervene between the normal and completely developed granite and the schists into which it is so plainly intruded. What is the cause of Nos. (2) and (3), the schistose granite and the gneissic granite? The former has certain suggestive points of petrographic likeness to the mica schists. It runs imperceptibly into the gneissic granite. The gneissic granite (No. 3) cannot be separated, in the field, from the protogine (No. 4).

It will be instructive to gather together some of the evidences, given by the authors, that go to show that these four terms are but steps in one great event, phases that depend on incompleteness of the process, or on difference of original composition and structure in an original sedimentary rock.

The authors say (p. 20): (1) The granitic type of the protogine is light colored, with variable grain, often very fine, with black mica evenly disseminated, with great regularity, in the mass. The gneissic type is usually of a darker color, greenish, and always more or less schistose. It separates more easily into layers than the foregoing. Plagioclase feldspars occur in both, in the latter in large white crystals. "All forms of passage between these two types are found." Thus, the enlargement of the feldspar crystals of the gneissic type transforms the rock into a true augen-gneiss the large feldspars of which with square sections sometimes measure five millimeters in length by two or three in width, and are alligned parallel. The color of the rock then becomes lighter, and the fragments that it contains more separated. Then the orientation of the feldspars disappears, the schistosity diminishes more and more, and the feldspathic element is dispoesd in all directions with respect to itself, and there is formed a rock still granitic, but of a type almost prophyroidal. At the same time the basic element marks out in the rock real lines or trains analogous to those of particles carried in suspension in a viscous liquid."

(2) These two types of granitic rock are not capriciously and irregularly distributed in the midst of the protogine. The true granitic type forms the southern slope of the massif, the col du Geant, the Grandes Jorasses, monuts Roux, the Dolent, the peaks of Planereuse, the Portelet, the summits of the Chatelet and of Breya, where, further, the grain of the rock becomes remarkably fine. But the gneissic varieties on the contrary are found in the neighborhood of contact of the protogine with the schists, and also in the central area of the massif where they appear to be arranged in lines along more or less definite axes, viz: between the Grandes Aiguilles and the summit of the Grandes Jorasses (p. 21). While the authors declare it is impossible to define the limits of the different parts of the gneiss, owing to the transitions to granite, as mentioned, they state that in general along certain axes the gneissic belts are manifest and separated one from the other by zones in which is evolved the granitic type. Further, intercalated in the midst of the gneiss are bands of real mica schist. In total, therefore, the mountain is composed of two great zones, more granitic than gneissic, enclosing between them a region where the protogine is more gneissic and schistose, a region which corresponds to a great central depression.

(3) The mica schists are accompanied by amphibolites.

(4) While there are distinct apophyses of the protogine

that penetrate the schists in an intrusive manner (p. 22) there are other places where there is a gradual passage from the schists to the protogine (p. 23) through gneissic and more or less augen types. This occurs at the "angle" of the Mer de Glace, at Aiguille des Grandes Mantels, at the peak des Rachasses, in the summits that overlook the glacier d'Argentières and des Rognous. It is the same on the opposite side of the glacier d'Argentière and in the valley of the Durnand; also at the stairway from Six des Orques to la Gurra and in reascending under the summit of Grande Becca, and elsewhere. Here the protogine passes insensibly into gneissic varieties. In the same gorge of Durnand "are seen first schistose bands, which little by little become more gneissic and which pass evidently to protogine."

These field appearances are identical with those which the writer has described in the final report of the Minnesota geological survey and which, prior to careful petrographic examination, seemed to him conclusive to prove the cotemporaneity of origin of all rocks concerned, and also the origination of all the igneous characters of the granite and of the gneiss from intense metamorphism and even fusion of the elements of the mica schist. The gradual transitions occur, under this hypothesis, where the original strata were not completely fused and displaced or were of differing composition, and the abruptly intrusive contacts where the plastic or molten matter accompanied and aided by hot water, was carried amongst the still infused rocks of the original terrane of the region. Where this transference was more gradual, and was largely due to water solutions, the pegmatitic structures were formed.

There is an essential difference, as relates to the schists, between these hypotheses. According to the authors the schists, as schists, preceded the granite. According to the writer they are cotemporary with the granite, and represent the lower terms of the same process that gave origin to the granite.

(5) The silica of the protogine is found to vary from 66 to 76 per cent. which shows a granite relatively acid, distinguished by that fact from the granite which forms crystalline zones exterior to the massif of Mt. Blanc. These variations

in acidity in the protogine the authors believe cannot be due to a lack of homogeneity in the original magma, but are to be attributed to modifications, more or less local and partial, resulting from the action of the crystalline covering, or the schists, upon the rock "de profondeur." Going beyond the massive nucleus, the authors find that the surrounding schists having 59.30 per cent of silica, are still less acid than the surrounding gneissic rock. In other words, that which is the most acid rock of the series is that which presents the strongest igneous characters, and which has most frequently and effectively penetrated the less acid in the form of bosses and dikes. The degree of acidity varies pari passu with the degree of fluidity of the rock considered. Such difference in acidity has frequently been appealed to to prove the genetic difference of the schists from the granite. There is no more obvious or common remark than that a crystalline rock, such as a granite, resulting perhaps from a fusion of fragmental materials, ought to contain substantially the same degree of acidity as the aggregate of the materials from which it was derived. There is nothing more evident. But it cannot be inferred from this that the granite at a definite point of intrusion should show the same degree of acidity as the schists which it intrudes, for the very fact of the intrusion implies that the granite has been moved from the point at which it may have originated, and hence that it may have started with a greater amount of acidity. If the action of quartz under metamorphism be considered a moment it will be found as a general law that the more acid rock material fuses sooner than the less acid. Quartz is the most mobile under metamorphism of all the rock-forming minerals. It is both first and last to show the effect of metamorphism. If such metamorphism be continued till it results in plasticity or fusion, it is an inevitable consequence that the most acid material would first become plastic. Hence, in all cases, when not disturbed by abnormal or accidental conditions, acid intrusives are found penetrating the less acid schists. Acid nuclei, in granitic mountain districts, are surrounded by less acid rocks, and inclusions of the less fusible schists are found in the granitic mass. In all cases, whenever a single epoch of metamorphism is considered, the more acid intrudes the less acid. In the rare case of dikes more basic than the enclosing rocks, they are to be attributed perhaps to later disturbances, at least to disturbances that penetrated to deeper levels and involved rocks that are genetically isolated from the rocks which they cut.

(6) The authors enter largely upon the examination of the fragmentary inclusions of the schists in the protogine, and then upon a description of those extended ridges of gneissic schist which maintain their form and direction over remarkable spaces, although embraced in the usual facies of the protogine. As to the former the authors reach the conclusion that they are masses detached from the original schistose terrane and do not result from basic segregations from the magma of the protogine. With this conclusion there can be little, if any difference of opinion. In regard to the latter, they find that these bands exhibit evident insensible transitions to the protogine, and are very frequent. "These schistose intercalations are much more frequent than has been supposed hitherto, and it would be an error to designate the massif of Mt. Blanc a compact nucleus of protogine" (p. 61). As they are less resistant than the protogine they are easily eroded, and give rise to cols and depressions. The authors have discerned the importance of the relations of these extended bands to the protogine, in the formation of any theory of the genesis of the massif of Mt. Blanc itself. In the col du Geant these schistose alternations appear with intervening protogine of differing types (p. 65). They reach the conclusion that they are local intercalations of the schist in the protogine, or true synclinals of the overlying schistose mantle, isolated and enveloped in the protogine, but apparently sometimes of a rock somewhat later than the schists; but a greater portion of the inclusions are analogous to the crystalline schists that flank the protogine. They cannot, in any case, be attributed to a dynamic crushing of the protogine.

To the writer these great bands of less granitic rock, sometimes approaching veritable schist, appear to be remnants of the original fragmental terrane, exhibiting all the transitions to protogine, and the same modification in lithology, that are exhibited by the mica schists. They are central instead of marginal, with respect to the protogine, a fact which may be attributed to infolding or to some great irregularity in the distribution of the force that gave origin to the general metamorphism.

The southeastern flanks of the Mont Blanc massif differ from the western. Here is found a great mass of acid schists, characterized by satiny lustre, and by porphyritic quartz. From the description given this group is plainly quite like certain Archean light colored sericitic schists which have been described in several places in Canada, and in northern Minnesota. They vary from exceedingly fragile to firm and dense rocks. They are often distinctly bedded by sedimentary action, and they also form large bands and bosses that rise into ridges or hills of considerable size and endurance. They frequently become strewn with quartz crystals and by ortho-clase. They then resemble quartz porphyry, and have sometimes received that name.* They pass, however, to a more green porphyritic rock, more basic, but still a part of the schist series, and also become a fine mica-schist more or less felsitic. In general this series is described by the authors under the term "porphyres quartzifères," but they distinctly take note of the intercalations of schistose rock and of granulyte (p. 89).

These schists and porphyries are allied to the schistose rocks of the Mont Blanc region rather than to the granite, and between them and the granite there is no known gradual passage. Yet the authors describe them from the view point of eruptive origin, and their schistose features they ascribe to dynamo-metamorphic crushing. They never contain vitreous matter, but quartz is developed as spongy grains embracing the other elements, as vermicular quartz and as micropegmatyte by entering into the feldspars. Of this secondary quartz there is a copious development. According to the authors these rocks under dynamic action take on such characters that they cannot be distinguished from certain horn schists, since the mica is drawn out and disposed in parallel trains, the quartzes are broken and the parts lie adjacent. In other cases the feldspars are similarly broken, and the rock has the aspect of a sericitic schist.

The chemical similarity of these rocks with the granitic veins, which cut the granite, suggests to the authors (p 109) that they are from the same magma, but consolidated in two different manners—a suggestion, however, which seems to have little validity since (p. 87) they form the cement of a conglomerate constituted of blocks and pebbles more or less rounded of granulyte and of protogine. There may, however, be some error of observation in correlating this conglomerate with the porphyry in general, since (p. 110) the contact of the porphyries with the protogine is said to be fresh and distinct, but often accompanied by intervening laminated or micaceous rock, and by the alteration of the protogine to aplyte and the occurrence of great numbers of veins of granulyte, in the protogine—features that seem to indicate the later date of the protogine. How it could be done the authors do not indicate, but they assume that the porphyries (here included this great series of sericitic rocks with their variations) have been subjected, locally, generallv and wholly, throughout their mass to dynamic forces more or less violent, which, when intensified, were able to destroy and grind up entirely the minerals of the first consolidation and to transform the rocks into true schists with a sericitic detrital aspect. Only calling to mind the authors' rejection of such a process in the case of the crystalline schists of the western part of Mont Blanc, for the origination of those schists from the crushing of the protogine, it is well to state here that according to studies carried out on similar rocks in northern Minnesota, these rocks are of oceanic origin, largely detrital, varying to graywackes, and that they originated cotemporaneously with others that are now mica schists, and that probably when they are consecutively traced from the southeastern flanks of Mt. Blanc they will be found to be inseparable from the mica schists which are penetrated by the granite of Mt. Blanc, as in the Val Ferret (p. 131), and that in general they escaped the profound metamorphism of the Alpine Archean by reason of their geographic location with respect to the center of greatest dynamic activity.

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*A notable instance of this is discussed by the writer in Vol. IV of the final report of the Minnesota Geological Survey, pp. 525-539.

As has been stated, the authors everywhere recognize the fact that the mica schists, the gneiss and the protogine (or granite) are linked by insensible gradations in areal relations and in petrographic and chemical association into one continuous petrologic series, the granite and the schist being the extremes. Not only are there such interlocking gradations, but there are similar major features that help to form the common chain. For instance (p. 117), there are isolated lentilles of pegmatyte in the schists, these being from one to twelve centimeters in diameter, and similar lentilles are developed in the gneiss, and these are sometimes generated at considerable distances from any known granitic mass.

All these minute, as well as the grander alterations in the schists of Mont Blanc, the authors ascribe to two agents which acted in conjunction, viz: dynamometamorphism and magmatic injection. The work is, in its general conclusions, an able contribution to the idea of endomorphism of intrusive rocks by the reaction of the intruded rock on the intrusive. Frequently the authors find a bordering band of gneiss or gneissic schist round about the central massif. This rock is sometimes classed as a more perfect metamorphic and sometimes as a gneissic part of the granite (p. 158). In either case the explanation is the same, and in all cases in which granitic aspects appear in the schists they are supposed to be due to the granitizing effect of granitic injection in the near vicinity. In other words the interchange of rock material was mutual and in opposite directions. The acid element entered the more basic schists, and the schists gave of their iron and magnesia to the granite. This process is reasonable, and in some degree certain, given the conditions precedent, but it assumes that the crystallization of the schists had been produced anterior to the appearance of the granite, instead of being the accompaniment of it. It is based also on an initial presumption which is not taken into consideration, but which is more fundamental. The chemical difference between the crystalline schists and the granite, from which the authors derive their conclusion of the different origins of these two rocks, is local and insufficient for their inference. It is probable that the schists, considered *en bloc*, including the sericitic schists and all the rocks associated with them, would give, in case of complete fusion, a magmatic rock identical or similar to the granite of Mont Blanc.

It seems to the writer, therefore, that there are lacking certain links in the argument for foreign origin of the granite. On the contrary the granite seems to have an autogenetic origin, because:

1. The widespread metamorphism cannot be attributed to contact effect. It is more of the nature of regional metamor-

phism. The immediate contact zone of the schists is not different from the schists at some meters distant from the granite.

2. It is hardly in accordance with known contact metamorphism, nor with any observed nor hypothetical case, that an intrusive rock should impart to the intruded rock siliceous elements that should arrange themselves in banded order, such as seen in the gneisses and gneissic schists extending for such distances in successive alternation.

3. It is impossible to believe that a granitic intrusion should cause the formation by infiltration of siliceous elements, of a banded gneiss or of granite within the schists at a distance say of a quarter of a mile from the known intrusive rock.

4. There is an easier and more natural explanation of the origin of the gneisses and schists, by supposing them to have existed as sedimentary strata of varying acidity, subjected to profound regional metamorphism, in the application of which were concerned both dynamometamorphism carried to actual plasticity of the fragmental materials, "magmatic" intrusion of some of the fused materials amongst the parts not plastic, and pneumatolitic transference of much acid matter amongst the same,forming pegmatytes and veins. This slow process was the cause of the total recrystallization of the fragmental materials *in situ*, sô far as the same were not extruded as lavas, thus accounting for the absence of vitreous matter. This method of origin does not require the extraction of so much silica from the magmatic granite and its dissemination amongst the schists as to leave it a basic rock, nor the loss of so much basic material by the schists as to render them acid: it only requires that the elements pre-existing in the fragmental strata shall be heated, pressed and re-crystallized *in situ* in the presence of moisture or rendered plastic. The granite and the schists and gneiss then would date from the same epoch, and be derived from the same elements, differing in kind because of the variability of the dynamic force in its geographic application, and because of the variability of the original stratified mass.

5. All the ascertained facts, whether structural, chemical, petrographic or petrologic, would find consistent causes, without resort to hypothetical or doubtful processes.

The phenomena that have been studied by the authors are parts of a larger problem than that they have applied themselves to. Their demonstration of the grading of the schists into igneous rocks of various kinds is very important, and such gradation can hardly further be questioned by geologists. Whether such igneous rocks (granite, gneiss, dioryte, syenyte) originated *in situ* from pre-existing rocks, mostly detrital, or are derived *de profondeur*, entirely strangers to the rocks that they are now in contact with, is a problem that remains to be solved for the Archean of the Alps. N. H. W.

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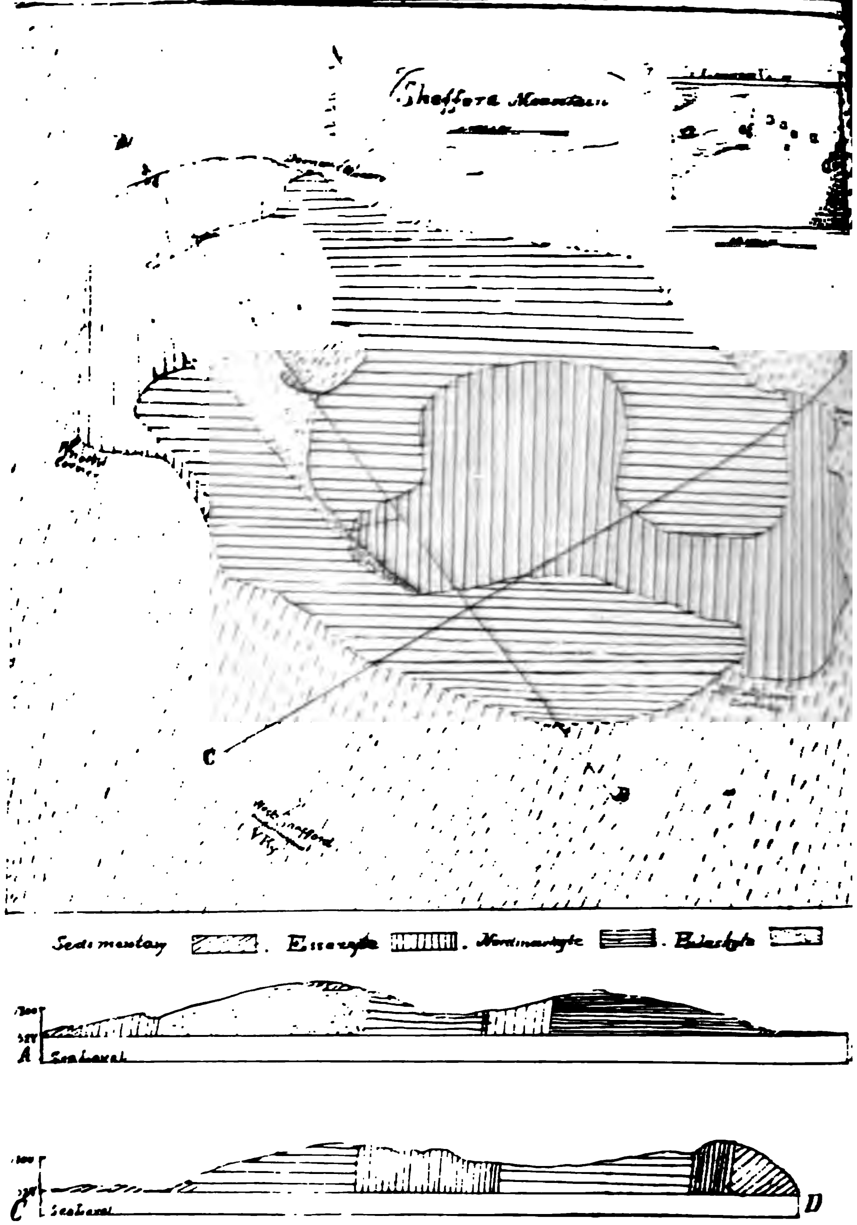
Shefford Mountain
C
D
Sedimentary
Essexyte
Nordmarkyte
Pulaskyte
A
Sea Level
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Sea Level
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ON THE PETROGRAPHY OF SHEFFORD MOUNTAIN.[*]

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PLATE XXI.

EXPLANATION OF PLATE.—The mountains indicated on the small map as crossing the St. Lawrence valley are the following in order from left to right: Mount Calvaire, Mount Royal, Montarville, Beloeil, Johnson (which is almost due south from Beloeil), Rangemont, Yomaska, Brome and Shefford. Rigand Mountain, which is beyond the western limit of this map, was considered by Logan also to belong to the series, but the recent researches of Mr. O. E. LeRoy (Bull. Geol. Soc. Am. 1900,) render the accuracy of this view extremely doubtful.

The broad flat valley of the St. Lawrence river, which separates the Laurentian highlands on the northwest from the hilly region of the Appalachian uplift at the southeast, is crossed in the latitude of Montreal by a line of volcanic hills, which appear at intervals of ten to twenty miles and rise to hights varying from seven hundred to twelve hundred feet above the surrounding country. Their igneous origin and intrusive relations have long been known,[†] the best known being Mount Royal, which gives its name to the city of Montreal at its foot.

The most easterly member of this series (see map) is the elevation known as the Shefford mountain, which covers an area of rather less than nine square miles in the county of Shefford about fifty miles east of the city of Montreal, and rises nearly twelve hundred feet above the surrounding country or about sixteen hundred feet above mean sea level.

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[*] Published with the permission of the Director of the Geological Survey of Canada.

[†] SIR W. E. LOGAN and DR. T. STERRY HUNT, *Geology of Canada*, 1863, p. 655, and also in earlier reports.
DR. R.W. ELLS, Annual Report, Geological Survey of Canada, 1894, part 3;
DR. F. D. ADAMS, Remarks, p. 74, ibid.
Canadian "Record of Science," Vol. VIII, No. 2.
A monograph on Mount Johnson, of this series, which will soon appear from the able pen of Dr. Adams, will be looked for with much interest by petrographers.

With the larger and adjacent mass of Brome mountain which work in progress shows to belong to the same series, Shefford mountain lies well within the folded belt of the Appalachians, though owing to the extensive denudation from which the region has suffered, this fact has little if any discernible influence on the topography of the immediate locality. The sedimentary strata which surround the mountain have been shown to be of Sillery (Lower Cambrian) and Lower Trenton age. They are found to wrap around the igneous mass of the mountain mantling it with a hardened contact zone to a hight of three hundred to one thousand feet above the surrounding country, according to the direction of glaciation. Above the latter hight the mountain rises upwards of two hundred feet, the summit being capped by an outlier of Trenton slate about a quarter of a square mile in extent. This preserves the cleavage, dip and strike of the similar rock at either side of the mountain, and is penetrated by dykes from the underlying igneous rocks.

From these facts together with the absence of tuffaceous material, and the general arching of the strata around the mountain, it is inferred that Shefford mountain is an uncovered laccolith rather than the denuded neck of a once active volcano. It is also evident that the depth attained by erosion in this part of the St. Lawrence valley cannot have been less than twelve hundred feet, and may have been much more. Its maximum does not seem to admit of any very reliable means of computation. The restoration of the folds of the strata, which are altogether worn down, would be the natural method of investigation, but the strike of cleavage, coinciding with that of the bedding, while the dip of the two is probably very different, so far complicates the question as to seemingly preclude the possibility of any but the most hypothetical calculations.

In the igneous mass three classes of rocks whose field relations show them to be products of as many separate periods of irruption (map) are easily distinguished. They are in order of intrusion, essexyte, nordmarkyte, and pulaskyte. Their comparative mineralogical composition may be shown as follows:

	Essexyte	Nordmarkyte	Pulaskyte
Constituents			
Essential	Plagioclase	Microperthite	Orthoclase
	Orthoclase		Plagioclase
	Hornblende	Augite	Hornblende
	Augite	Hornblende	Augite
	Biotite	Biotite	Biotite
Accessory	Apatite	Magnetite	Magnetite
	Magnetite	Sphene	Sphene
	Sphene	Apatite	Apatite
	Sodalite	Nepheline	Sodalite
	Nepheline	Sodalite	Nepheline(?)
Structure	Hypidiomorphic	Hypidiomorphic	Porphyritic
			Trachytic

Essexyte. This is a rather coarsely crystalline rock of a dark gray color and weathering to a rusty brown. On a fresh fracture feldspar is seen to be slightly the most abundant constituent, and by the aid of the lens part of it can be seen to be striated and hence triclinic. A black or dark brown hornblende is the most conspicuous of the dark colored constituents. This varies considerably in amount and in some of the contact phases makes up fully half the rock, but in general it is quite subordinate in proportion to the feldspar. In parts of the rock considered typical it is also exceeded in quantity by a light colored augite, and brown mica is quite abundant.

A mechanical separation of the rock was made by Mr. O. E. LeRoy at the petrographical laboratory of McGill University which gave the following results regarding the feldspars—when the specific gravity of the Thoulet solution, which was employed, was reduced from 2.689 to 2.651 much feldspar fell; between 2.651 and 2.562 much also fell, part turbid and part clear grains; between 2.583 and 2.524 a smaller amount, all turbid. There were no lighter constituents.

Grains from each of these specimens were mounted and ground for microscopic examination. The first was found to be rather broadly striated and to have an extinction angle as high as 36° measured on the albite twinning lamellæ. These are accordingly classed as labradorite. The second, in which the twinning lamellæ are finer, showed only very low angles of extinction in the clear grains, which are referred to oligoclase-andesine. The turbid grains of this weight are found to be either zeolitized labradorite or composite grains of orthoclase and a heavier constituent. The lightest constituent was found to be unstriated feldspar presumably all orthoclase. It fell in smaller amount than either of the others.

In the thin section of the rock the labradorite is found in better formed crystals, but in smaller amount than the oligoclase-andesine, while orthoclase, which can often be distinguished by its incipient alteration, is the least abundant of the three feldspars.

Augite is colorless and without pleochroism. It shows characteristic cleavage, nearly right angled, and extinction angles as high as 45°.

Hornblende is brown varying in shade from deep chestnut to yellowish. It is trichroic, the scheme of absorption being $\mathfrak{c} > \mathfrak{b} > \mathfrak{a}$. The greatest angle of extinction that was observed $c \wedge \mathfrak{c}$ was 27°.

Biotite in some instances is intergrown with horneblende, and in others encloses numbers of augite crystals promiscuously arranged, thus giving an excellent micro-poikilitic structure.

The structure of the rock is hypidiomorphic and the order of crystallization, the normal one for plutonic rocks. The ferromagnesian minerals enclose the basic accessories and are themselves generally of an earlier order of crystallization than the feldspars. Of the latter the labradorite has crystallized earlier than the oligoclase-andesine and both are cemented together by orthoclase.

The rock thus agrees essentially with the characters of the essexyte group, a near analogue probably being the augite dioryte of Rosita Hills, Colorado,* described by Cross (XVII, An. Rep. U. S. G. S). A specimen of essexyte from Salem Neck, Massachusetts, kindly given me by Mr. J. H. Sears of the Salem Academy of Sciences, agrees completely with some of the darker and more hornblendic portions of the Shefford mass.

The following are the results of (I) analysis of a specimen from Morriseau's quarry, Shefford, which, judging from the microscopic evidence, is probably the most acidic part of the intrusion;† (II) Augite-dioryte, Rosita Hills, Colorado; (III) Essexyte, Rangstock, Bohemia

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*This has been included by Prof. Rosenbusch in the essexyte group.—"Elemente Gesteinslehre."

†A few small grains of quartz were found in a section from this specimen. the only quartz that has been found in this rock.

(cited by Rosenbusch, loc. cit.); (IV) The original Essexyte, Salem Neck, Mass.

	I	II	III	IV
SiO_2	53.15	50.47	50.50	47.94
TiO_2	1.52	.51	1.91	.20
Al_2O_3	17.64	18.73	17.64	17.44
Fe_2O_3	3.10	4.19	5.41	6.84
FeO	4.65	4.92	4.02	6.51
MnO	.46	.11		
CaO	5 66	8 82	7.91	7.47
BaO	.13			
MgO	2.94	3.48	3.33	2.02
K_2O	3.10	3.56	3.02	2.79
Na_2O	5.00	4.62	5.52	5.63
P_2O_5	.65	.10	.92	1.04
CO_2	.39			
SO_3	.28			
Cl	.07			
H_2O	1.10	.58	.45	2.04
	99.84	100.09	100.63	99.92

Nordmarkyte. This rock was described under the head of granitoid trachyte by Logan (Geology of Canada, 1863, p. 653) as "being made up in a great part of a crystalline feldspar, with small portions of brownish black mica, or black hornblende, which are sometimes associated. The proportion of these minerals is never above a few hundredths, and is often less than one-hundredth. The other mineral species are small brilliant crystals of yellowish sphene, and others of magnetic iron, amounting together probably to one-thousandth of the mass."

To the essential minerals there should be added a nearly colorless augite, which commonly equals the hornblende in amount and is a rather more persistent constituent of the rock. The feldspar is almost wholly a microperthite, which as the following analysis by Hunt (Geology of Canada, 1863, p. 476) shows, answers approximately to an isomorphous mixture of albite and orthoclase molecules in the proportion of 3 : 2.

I. Feldspar, Shefford. Analysis by Hunt.

II. Kryptoperthite, Laurvik, Norway. Analysis by Emelin, Syenitpigmatitgange, p. 524.

III. Anorthoclase, Marblehead Neck, Mass. Analysis by Chetard, Bull. Mus. Comp. Zool., XVI.

IV. Approximate theoretical composition of feldspar having the formula $Ab_3 Or_2$.

Ridge trachyte of the Rosita Hills, Colorado. Hornblende in this rock is chiefly green in ordinary light as seen in the thin section, though a few of the largest crystals are brown resembling the hornblende of the essexyte, while the green is like that of the nordmarkyte. Both are trichroic with the same scheme of absorption, viz.: $\mathfrak{c} > \mathfrak{b} > \mathfrak{a}$ and extinction angles as high as 26°-27° have been observed in sections in the zone of the clinopinacoid. Augite when present is of the colorless variety described before.

Biotite occurs in large individuals but is on the whole less abundant than hornblende. The groundmass consists chiefly of short rather stout prismatic sections of feldspar which have a parallel extinction and are packed together in a close and nearly parallel arrangement, with a little allotriomorphic feldspar in the interstices. A little undetermined matter occurring interstitially amongst the feldspars was thought to be altered nepheline. It may, however, be only kaolinized orthoclase. A few striated sections appear which extinguish at low angles with the twinning lines and are probably oligoclase. They are unimportant in amount. The texture of the rock was found too fine to admit of a mechanical separation.

Its mineralogical and structural characters at once suggest the affinity of this rock to pulaskyte, first described by Mr. J. F. Williams[*] from Arkansas, a view that is also corroborated by the results of its chemical analysis. In the hand specimens it is generally somewhat lighter in color and finer in texture than the specimen of pulaskyte in the educational series of the United States Geological Survey at the petrographical laboratory of McGill University, and judging from the published description it is very similar to the porphyritic syenyte from Saline county, Arkansas.[*] This, however, was considered by Williams as scarcely to be distinguished from pulaskyte, occupying the same position amongst the igneous rocks of Saline county that pulaskyte holds at Fourch mountain.

A variety of this rock in which hornblende and augite are replaced by ægerine-augite approaches very closely to the sölvsbergyte type. It is apparently closely related to the acmite-trachyte of Profs. Wolff and Tarr. (Bull. Mus. Comp. Zool., Cambridge, 1893) afterwards re-named by Prof. Wolff as tinguayte, var. sölvsbergyte. In that rock, however, the bisilicates are in the form of ægerine and augite intergrown, instead of a single mineral of intermediate composition as at Shefford.

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[*] "The Igneous Rocks of Arkansas," J. F. WILLIAMS. *An. Rept. Geological Survey of Arkansas*, Vol. II, 1890.

[†] Ibid, p. 140 and seq.

	I	II	III	IV
$Si O_2$	59.96	60.03	59.01	58.70
$Ti O_2$	.66		.81	trace
$Al_2 O_3$	19.12	20.76	18.18	19.26
$Fe_2 O_3$	1.85	4.01	1.63	3 37
FeO^2	1.73	.75	3,65	.58
$Mn O$	.49	trace	.03	.10
$Ca O$	2.24	2.62	2.40	1 41
$Ba O$	.12			
$Mg O$	.65	.80	1.05	.76
$K_2 O$	4.91	5.48	5.34	4.53
$Na_2 O$	6.98	5.96	7.03	8.55
$P_2 O_5$	.14	.07		.10
$C O_2$	none			
$S O_3$	.08	none		
Cl	.14	none	.12	
H_2O	1.10	.59	.50	2.57
	100.17	101 07	99.98	100.00

I. Pulaskyte, Shefford. Analysis by Connor.
II. Pulaskyte, Fourch Mountain, Arkansas. Analysis by Brackett and Smith.
III. Umptekyte, Red Hill, Moultenborough, New Hampshire. Cited by Rosenbusch, loc. cit.
IV. Sölvsbergyte (Acmite Tracheyte), Shield's River, Crazy Mountains, Montana. Analysis by Melville. Described by Wolff and Tarr.

Contact Facies.

The endomorphic contact facies of each of these rocks is marked by an increase in the proportion of the ferromagnesian constituents and the appearance of nepheline and sodalite amongst the accessory constituents. The essexyte thus becomes a very dark rock of which hornblende alone sometimes makes up about one-half and frequently approaches very nearly to the character of theralyte. The nordmarkyte shows also a great increase of the basic constituents, especially biotite. The feldspar too changes from microperthite to kryptothousands of feet, and in similar zones the separation of different beds is almost as great, yet the biological expression is not extremely contrasted throughout and, as the French translator of Matthew's paper has remarked[*] (Soc. Mal. de Belgique; Ann. 4th, 1888, p. 552), the lowest beds holding the earliest trilobites offer no significant evidence, in their trilobitic remains, of embryonic or formless stages of development. That is while larval conditions may appear they are stages in an individual life history, not fixed preparative stages in the development of a phylum.[*] It is logical, or at any rate natural to assume that throughout the long periods of time antecedent to the Cambrian age these preparative stages were evolved and completed, but as a matter of contemporaneous geological history they have not yet been discovered, and possibly, from their perishable nature, cannot be. The trilobites of the Cambrian in their numerical abundance, their very considerable specific variation, their sudden appearance in the paleontological series, and their apparent chronological isolation justify the characterization of a *biological crisis.* The only way to throw light upon this problem is to consider the circumstances of similar biological multiplications and intensity in living faunas.

It would seem certain that the trilobites enjoyed an almost complete immunity from those accidents which today devastate the young broods of crustaceans, while the almost infinite resources of multiplication with which this phylum is endowed permitted unrivalled opportunity for propagation and distribution. Profs. Sars and Boeck have pointed out the numerous dangers to which the young lobster is exposed and which must necessarily greatly reduce the total numerical maximum attainable by that animal. The young larval lobster suffers from the attack of fish, the entangling effect of sea-weed, the injurious physical character of the coast, whither currents may transport them, sudden changes of temperature,[†] and impaired vitality from abrupt or delayed discharge from the parent.

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[*] There can be of course, no demurrer to the conclusion that many genera of Cambrian trilobites, perhaps the more common and generally noted, represent protaspic stages in more advanced and later evolved genera, but as found they are mature defined and individualized genera. Dr. Beecher has indeed said that the Opisthoparia (Conocoryphidae, Olenidae, Asaphidae Lichadidae, etc.) probably culminated during the Cambrian.

[†] Although in 1879 lobsters with roe were successfully transported to the west coast and "had with them over a million eggs nearly ready to hatch," [illegible] ults have apparently flowed from the experiment.

Fish were absent in the Cambrian seas, mollusca had reached no formidable growth, the shores were devoid of excessive algous occupancy, and probably thermal conditions were benign.

If we assume for the trilobite the fecundity of the ordinary crustacean, which in the lobster presents a phenomenal intensity, since to the enormous number of eggs in a female the practical impregnation of every egg superinduces an almost unparalleled generative success, and if we add to this the most optimistic circumstances of its environment, the great development, wide distribution and individual numbers of the Cambrian trilobites does not seem so extraordinary. In other words a [illegible] is coincident with the period of greatest internal and external harmony. When with the congenital forces of procreation, the physical factors are so encouraging and sympathetic as to give them their extreme amplitude of action, the zoological result must at least be surprising.

In Semper's contributions to the influence of surroundings upon the animal organism (International Science Series, 1881) he has pointed out the varying influences of food, temperature, atmosphere, water motion, currents, subsidence and upheaval, ocean waves, pressure, and the influence of living surroundings. Arranging these for the purpose of realizing the possible biological results amongst the trilobites of the Cambrian we may select food, temperature, water motion, currents and movements and living surroundings. These must all have been reasonably favorable, and we can from geological evidence establish their probable persistence and reinforcement.

The crustaceans of the sea today feed upon algae and young marine animals. The Cambrian sea [illegible] furnished algae in abundance [illegible] especially there is reason to think that [illegible] and coelenterate life was omnipresent [illegible] raised in the former section of this paper that the sea shores witnessed the earliest [illegible] marine [illegible] pods, sponges, medusae [illegible] ciously eaten by lobsters and crabs [illegible] and furnished an unlimited food supply to the somehow rapidly advanced type of crustacean life.*

Granted that the food supply was abundant Semper's statement directly applies. He says (p. 65) "it is self-evident that an optimum of nutrition can alone insure the normal functions of all the organs; if it does not attain the optimum, the functional activity of *all* the organs is impaired; modifications at the same time occur in their structure, *i. e.*, the animals grow leaner because incapable of exercising their sexual functions, etc." The sexual powers of the Cambrian trilobite so far as food strengthened or increased them were probably well developed.

Temperature was propitious. It has been over and again demonstrated that warmth vitalizes the generative functions. There is a wide range of differing capacity in this respect in animals, and the familiar term ***eurythermal*** has been applied to those organisms which endure contrasted temperatures.

But the fact is almost universal that heat is stimulating and helpful, to animal life and its functions. It has been observed that snails of the warm Mediterranean region are quickly brought to sexual maturity and that "species of the same genera, perhaps even the same species, in damp and cold climates do not produce a new generation until they are fully grown while in the dry warm region of the Mediterranean they have produced two generations before they are fully grown" (Semper). Semper has himself observed that the larvæ of *Branchipus* and *Apus* hatched out in less than twenty-four hours at a temperature of 30° Cent., but at 16°-20° they required some weeks.

Today our shore crustaceans require the warmth of summer to bring their powers of fecundation into activity, but it can readily be understood that the Cambrian trilobite in an equable and hot climate, such as in all probability, and, as almost universally recognized, prevailed at that period, may have excluded two broods or more in the seasonal year, while the rapidity of development of the larvæ into mature forms, and their early acquirement of sexual activity may have still further reinforced the numerical results. It was a time when as at the Philippine Islands today, true periodicity had disappeared, and eggs, larvæ, and propagating individuals may have been found at all times.

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* The omnivorous propensities of the modern crayfish, have been characterized by Huxley, "few things in the way of food are amiss to the crayfish; living or dead, fresh or carrion, animal or vegetable, it is all one." Trilobites are not crayfish, but it is reasonable to infer that the elements of nutrition in the whole group of crustacea are not dissimilar throughout.

The remaining factors that might have influenced the successful development of trilobites in the Cambrian seas were water motion, currents, land movements, and living surroundings.

The prevalence of high waves, the rushing in and out of heavy volumes of water, would have been extremely detrimental to the lives and propagation of crustacean animals if they were exposed to its mechanical violence and its accompaniment of moving stones etc. But the evidence points to the occupancy of shallow shores or basins by the Cambrian trilobites and those generally of a sandy or muddy nature, in which no disturbances inimical to their quiet and continuous existence appeared. The conditions of a slowly advancing or receding sea (vide Chamberlain, Jour. of Geol., Vol. VI, p. 449) permitted their enormous multiplication along the thermally benign coast areas, while the absence of rapid or destructive currents seems certain from the usually conformable and exact lamination of the beds where the trilobites occur in large numbers.

Finally their living surroundings were almost invariably favorable, food was abundant and enemies absent. Their specific and generic variations are not so easily explained. They certainly point to an inheritance of characters developed far back of the Cambrian day, characters also quite deeply established, and ineffaceable by interbreeding or pan-mixia.

The Cambrian faunal trilobite expression is that of a broad anterior shield more or less genally extended, a conoid head, an extended series of pleural segments, and a reduced or absent pygidium. Their separation into species and even genera suggest inherited anomalies in their evolution from the annelid (Bernard), and even point to divergent origins from differing annelid types. Bernard (Quar. Jour. Geol. Soc., Vol. 50) has described trilobites "as fixed specialized stages in the evolution of the Crustacea from an annelidan ancestor, which bent its mouth round ventrally so as to use its parapodia as jaws." Now it seems inconceivable that if evolution brought about this change a single individual annelid or one restricted form of annelid started the process. However conceived, a number of forms or annelidan individuals gradually began this curious change, and it can be safely emphasized that such a change was not *begun* under the impulse of *natural selection*, since the turning under of two, three or four segments (somites) of a worm-like organism, so as to bring its mouth against its ventral surface would hardly prove a favorable position for competition with more extended and pliant congeners.

If the inflection of the annelid body began at several distinct localities simultaneously the stages of evolution may not always have been the same; were not likely to be. And if this was so, there seems to be no need of presupposing even a geographical connexion between separated geological areas, having similar species of trilobites; as the evolutionary stage might have, must have, eventuated at many places or more than one place, at the same time. The hypothesis of a single annelidan ancestor for the trilobites, or even many *identical* ancestors seems inadvisable, and the hypothesis of a single center of origination and distribution even more so.

But examining the Cambrian trilobites the impression deepens that the influence of environment and habits is discernible, and that in the case of *Dikelocephalus*, *Aglaspis*, and *Crepicephalus*, something like natural selection is hinted at. For in the first instance, that of the influence of environment and habits, it is seen in the assumption of the broad cephalic and genally rounded shield. The first form of the cephalon of the involuted worm would naturally have been in an inflated rhombic outline and the gradual development of an expanded crescentic and more flattened shield an adaptation to its new habits and new surroundings. It is further safe to assume that the evolution of a trilobite from a worm, began in the larval stages of the latter in order to preclude the almost impossible thought of a *fixed* mature organism undergoing changes that would so react on its own embryology as to establish there a new series of metamorphoses. Take for instance the larval stage of the worm *Polygordius*, when from the enlarged cephalic mass the segmented body elongates, does not a condition supervene which might readily give or has given rise to a trilobitic phase?

However that might be the primordial trilobites seem, as the earliest crustaceans, a good illustration of the influence of environment. They lived in shallow seas, along sandy shores, and occasionally in muddy and calcareous slimes. But in their motion over the sea bottoms or their occasional excursions into deeper water they constantly encountered an opposing pressure and the effect of mechanical resistance, in accordance with the principles of histological modifications enunciated and established by Ryder, would have hastened the growth of the trilobitic head-shield. Ryder has written of the hard exoskeleton of chelonians and armadilloes,* "the origin of dermal ossifications is to my mind rationally explained by supposing the bioplasm of each dermal cell as sensitive and irritable to rude or violent external impacts, which, oft repeated, act as stimuli of growth force, determining certain tracts of these cells as the nidus within which osseous particles eventually appear as nuclei of the future defensive dermal bony system." The same theorem has received discussion in Prof. Cope's well known address on "Relation of Animal Motion to Animal Evolution," and a capital illustration of one phase of it is found in the strengthened lateral teeth in the plates of Chitons exposed to the mechanical violence of waves. (See Pilsbry.)

The change from a creeping habit to a swimming one would have, in accordance with this law, developed a hardening chitinous envelope over the head parts of the metamorphosing annelid, wherever the stimulating effects of pressure, against water, sand, or mud, were felt. Environment and habit, on the assumption of an annelidan origin, must have had a sensible influence in producing primarily the crescentic shield-shape of the trilobites glabella.

Natural Selection may have played some part in the rapid extermination of *Dicellocephalus, Aglaspis* and *Crepicephalus.* They are found with an extremely limited range, and, in the appreciable vertical distribution of *Dicellocephalus,* the occurrences are sporadic. Broad expanded shields or blunt shouldered ones would have generally proved unfavorable to continued existence along a stormy or tide invaded coast. In the former case their owners in shallow water would have been readily overturned and drifted up upon the beach, and the difficulty of returning to their normal position increased by the flatness and width of their frontal carapace.

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*On like Mechanical Conditions as producing like Morphological Effects. Amer. Nat., 1878, p. 157.

Today the awkward and prolonged efforts of a Limulus to return to its normal position when upside down are finally rendered successful by the assistance of its telson. It can be pointed to as illustrating an effectual line of development which might have assisted the primordial trilobites, viz., flat and sloping heads, features absent in Dicellocephalus, Aglaspis, Chariocephalus, Crepicephalus &c.

Again it seems probable that the extended pleural segments of the primordial trilobites were correlated with a weak articulation. This early crustacean failed in rigidity and coherence. It fell apart easily upon impact or collision or exposure. The line of favorable development in this case which would have strengthened the trilobite was in the direction of a shortened thoracic extent and an increased pygidium. But the surfaces of attachment for egg sacs were multiplied in the Cambrian multi-pleural forms and the intensity of multiplication was thereby augmented.

From the early Cambrian Olenellus and the Paradoxides through Conocoryphe and Ptychoparia etc., to the Agnostus, Illaenus etc., there is an evident relative shrinkage in the cephalic shield, a condensation of the pleuræ, a loss of pleural spines, a growth of the pygidium, all organic movements in the direction of strength and solidity. Environment and habit and selection played important parts in aiding a determined development, but the remarkable and overshadowing importance of crustacean life in the Cambrian day must have resulted from an optimum in the conditions then favorable to their growth, and from the ease also with which evolutionary processes formed them from an annelidan ancestor.

This latter observation deserves a moment's clearer consideration. The development of a trilobite from an annelid would have been, humanly speaking, a more natural and hence a more quickly completed change than that of a brachiopod from the same original organism. If such evolutionary processes began at the same time, at a given period, subsequent to their inception, the trilobite phylum might have been numerously represented, when as yet the brachiopodous life had formed but slightly. In the evolutionary change from one organic form to some possible organic deduction from it, the generative organs are probably the last to become fully habituated to an altered form and nature. There would certainly be less violent change from the generative functions of a worm to those of a trilobite than from the same to those of a brachiopod, and along some line of elucidation like this we may partially explain the early preponderant profusion of trilobitic forms.

Another instance of a *biological crisis* is the abundance of lamellibranch remains in the Upper Devonian in the Hamilton and Chemung rocks of New York. There is presented in the New York Hamilton, an extraordinary development of lamellibranchs exhibiting a marked and almost sudden display of genera which continues with an increased numerical intensity and a noticeable similarity of types into the Chemung, to be practically obliterated in the Lower Carboniferous. The phenomenon seems also to distinguish an optimum of conditions for growth and variation, and, as in the case of the trilobites, must have resulted from a conjunction of a favorable environment and vital force. There is certainly a well marked development of bivalves in the Devonian and along with the appearance of new genera, a multiplication of species and an immense increase in individuals.

In the studies of paleozoic lamellibranchs so carefully prepared of the N. Y. Geological Survey, though unfortunately incomplete, a tabulation of the species from the different geological horizons from the Schoharie to the Waverly affords this interesting summary:

Schoharie	Corniferous	Marcellus	Hamilton	Genessee	Portage	Chemung	Catskill	Waverly
16	41	21	174	2	9	252	1	35

The showing of species for the Waverly is misleading. In the Preface (Vol. V, pt. I.) the authors (Drs. Hall and Beecher) explain the comparatively few species from this horizon as due to delay, interference, and their solicitude to bring their work to completion and publication.

The decreased number of species in the Waverly may therefore not be of much significance, but the evident fact of a progression forward from the Corniferous, the unquestioned lamellibranchiate evolution of increased numbers and species to the Chemung and the obvious gaps between the Corniferous and Hamilton, the Hamilton and Chemung, the Chemung and Waverly are.

Such gaps are an evident indication of a suspension of molluscan life incident upon unfavorable conditions and the withdrawal of the previous molluscan faunas elsewhere, as there can be no doubt of the continuity of this lamellibranchiate life through the Upper Helderberg, Hamilton and Chemung periods. Those conditions were shore conditions, shallow water, continental drainage and more or less disturbed marine tracts wherein storms or waves easily dislodged shells, and caused their withdrawal to deeper water. On the other hand the increase of species in the populous periods after these gaps, would seem to indicate an acceleration in the production of species, which must have begun in some areas to which the molluscan fauna retreated upon the invasion of their previous habitat by the conditions represented in the Marcellus, Genessee, Portage and Catskill.

The Marcellus group certainly does not represent a period totally inimical to molluscan life. It only marks a decresence of the previously crowded fauna of the Upper Helderberg and holds within it (Clarke, Livonia Salt Shaft, 13th Annual Report, N. Y. State Geologist, p. 156-158), a succession of faunas which are both reminiscent and prophetic, being Helderbergian and Hamiltonian in nature, besides its own indigenous fossils. The Marcellus, as the Genessee, presents, however, an instructive illustration of displacement and conflict. It introduced conditions, and brought with it a life contrasted with the conditions and life which marked the Upper Helderberg, and yet in those conditions and life there remained a struggling survival of the latter, and many of the lamellibranchiate genera pushed their way through to the Hamilton, while on the other hand the Hamiltonian fauna moving landward inserted itself "*prenuncially*" (Clarke) in the Marcellus areas.

Similarly in the Genessee, outside of the fundamentally characteristic "*intumescens*" fauna, the relics of Hamilton life, and the precursors of Chemung life are found. But in both these cases we are evidently in the presence of oscillating conditions; we have shown us again, what seems so universal and constant a predicament in the geological record, an extending continental margin with a previous deeper sea life pushed away from the continental sediments and existing under stress and competition (See Chamberlin, Jour. of Geol., Vol. VI, p. 449.) in narrower precincts, itself surging back again upon the continental shelf, somewhat modified by its long absence, when the deeper water conditions supervene nearer the land surfaces. Yet if the shallow water character of the Marcellus and Genessee is conceded the presence in both of ammonoids seems contradictory. Dr. Clarke (50th Ann. Rep. Regents, p. 137) insists that in the Genessee these goniatitic remains are "not a mechanical invasion, a congeries of flotation, but is in harmony with its components in mode and direction of derivation." Deferring a longer reference to that fact, and reverting again to the disappearance, sometimes partial only, of the lamellibranchs in the Marcellus and Genessee, we must conclude that the shallowing of the water was not an entirely determinate cause expelling them, but that some associated feature in the character of the water, or bottom, brought it about more explicitly. This feature may be the widely disseminated bituminous contents of these shales. There seems to be evidence that this bituminous matter was, to some extent at least, derived from the land and that it was disseminated through the water probably coincident with land storms, bringing on inrushes of fresh water, and overwhelming accessions of mud.

It is well known that in the development of oysters, clearness of water, permanence and hardness of bottom, still and undiluted marine conditions favor the survival of the young. And this is also true of other bivalves. Mr. R. E. C. Stearns in his suggestions as to the best means of transplanting the edible bivalves, (*Glycimeris, Saxidomus, Schizothoerus*) of the Pacific coast to the east, has stated that such conditions should be measurably secured, though in the case of some of these shells, slime, alluvium, drainage and refuse matter did not actually exterminate, or even diminish them. Of course the Marcellus conditions if unfavorable to an expansion of lamellibrachiate life were not faltal at all to its continuance. *Panenka* and *Lunulicardium* survived in both the Marcellus and Genessee and Portage.

If then the Marcellus, Genessee and Portage were marked by a diminished lamellibranchiate life, and if this diminution arose from the too strong prevalence of shore conditions; floods, suffusion of particles, dirty water, brackish currents, sand-flats, tidal extremes etc., what does the general continuance of the lamellibranchs and their increase from the Upper Helderberg to the Waverly signify?

Such a continuance in genera, as the following table shows is unmistakable.

TABLE OF GENERA

UPPER HELDERBERG	HAMILTON	CHEMUNG
Aviculopecten	Aviculopecten	Aviculopecten
	Actinopteria	Actinopteria
	Allocardium	
Conocardium	Conocardium	Conocardium
	Cytherodon	
	Cimitaria	Cimitaria
Cypricardinia	Cypricardinia	Cypricardinia
		Crenipecten
Dystactella	Dystactella	
		Edmondia
		Ectenodesma
	Elymella	
Glyptodesma	Glyptodesma	
	Gosselettia	
		Glossites
	Goniophora	Goniophora
Grammysia	Grammysia	Grammysia
Lyriopecten	Lyriopecten	Lyriopecten
Leiopteria	Leiopteria	Leiopteria
	Leptodesma	Leptodesma
Limoptera	Limoptera	
	Leda	
	Lunulicardium	Lunulicardium
Mytilarca	Mytilarca	Mytilarca
		Modiola
Modiomorpha	Modiomorpha	Modiomorpha
Microdon	Microdon	Microdon
	Modiella	
	Macrodon	Macrodon
Megambonia		
	Nucula	Nucula
	Nuculites	
Nyassa	Nyassa	
	Orthonota	
Palaeopinna		
Pterinopecten	Pterinopecten	Pterinopecten
Pterinea	Pterinea	Pterinea
Panenka	Panenka	
Paracyclas	Paracyclas	Paracyclas

Pararca		Pararca
	Palaeoneilo	Palaeoneilo
	Prothyris?	
		Ptychopteria
		Pteronites
	Phthonia	
	Pholadella	Pholadella
	Ptychodesma	Ptychodesma
	Palœanatima	
	Palaeomya	
		Prorhynchus
	Solemya	
	Sphenotus	Sphenotus
Schizodus	Schizodus	Schizodus
	Solen	
		Sanguinolites
	Tellinopsis	

The genera of the Upper Helderberg are twenty-one, of the Hamilton forty-three, and of the Chemung thirty-five. There is a sensible identity in the genera of the last two formations, with an increase of species in the Chemung. There would seem to be indicated here a biological crisis; that a group of organisms enormously expanded under favorable circumstances, and that when they were forced out of their habitats, they came into competition with each other in a smaller environment, and upon each return, brought back an increased number of species, possibly referable to that competition as a cause.

As in the case of the trilobites, this crisis suggests something like *impulse, vis a tergo,* assisted indeed by natural auxiliary conditions. There would seem to be no especial reason why, from the Potsdam to the Devonian, the lamellibranchiate phylum, which was certainly in evidence throughout that long time, might not have reached as wide a circumscription of species and genera as it did in the last named era, any more than there seems any special reason why the trilobites in the Cambrian attained a development quite unrivalled since. It has been suggested in this paper that evolution could have acted more rapidly in the production of trilobites than it did in the associated life, reinforced by very favorable circumstances for their multiplication. Can it be conceived that in the case of the lamellibranchs there were inherent obstacles to evolution, and a protracted restraint ensued before this life group could store up enough biological spring to jump forward into formal (generic and specific) diversity? Is evolutional aptitude, like individual endowment in men, a function of organization? Or is all evolution conditioned upon physical circumstances. In many ways it must be, and perhap this long quiescence of potential variability in the lamellibranchs proves it.

At any rate we are afforded a glimpse at a cause for variation in the succession, shown in the New York palaeontological studies, of the Devonian bivalves. It is this.

The recession of the sea causing the shallow water formations of the Marcellus, Genessee, Portage, Catskill, was always succeeded in the Hamilton, Chemung, and probably Waverly, by an increase of species. It would then appear probable that the expelled genera in each instance, driven to more restricted areas, probably in deeper water, came into some sort of competition, and species, as fixed variations, were stimulated to appear, and in the next encroachment landward multiplied. Comparing the Chemung with the Hamilton the genera prominently exhibiting this expansion are *Pterinea, Actinopteria, Leptodesma, Glossites, Mytilarca,* with the new genera *Crenipecten, Ptychopteria Edmondia.* These genera and their species give some evidence of deeper water origin in their smaller size. Naturally this statement cannot be made into a sweeping deduction, but it has a preponderant application. The large sized genera *Limopteria Glyptodesma* are Hamilton, the small sized genera *Crenipecten Edmondia* are Chemung, and throughout, with many exceptions, the impression of the Chemung species is that of smaller sized individuals. The voyage of the Challenger lends support to this view and Sir Wyville Thompson has himself said "my present impression is that although life is thus universally extended, the number of species and of individuals diminishes after a certain depth is reached, and that at the same time their size *usually decreases.*"

If the increase of species has resulted from competition in circumscribed sections of the sea-bottom, this crowded condition may have had also some influence on size.

The assumption of recurrent periods of competition with the consequent multiplication of species introduces what has always seemed a difficult inquiry, how the process of the *survival of the fittest* works amongst such organisms as bivalve shells, for the most part, sessile sightless animals; how advantages of form or habit work for the preservation and continuity of the differing species. Strengthening of hinge structure, increased solidity of the shell, lengthened siphonal tubes, stronger and more muscular feet, flattened shells to avoid impact of currents, roughened or spiculate surfaces for attachment to mud, rocks, sea-weed etc., attenuaton of form for insertion in crevices, development in byssus, gaping mouths, shoulders, elongation, curving backs, are features that might gain accentuation, and variously help their possessors to improved prospects in the life-race. And certainly many of these features are conspicuous in a review of the Devonian lamellibranchs, but specific distinctions based on a slightly more accurate form, a more nasute outline, a triangular form, a lengthened or shortened anterior or posterior margin, a variation in surface sculpture, a higher umbonal prominence, proximity or recession of beaks, while all doubtless justly weighed as specific marks, apparently have no conceivable reference to any particular advantage they bestow. They may be indeed steps in an advantageous march of modifications.

Schizodus shows a lengthening posterior edge, and both increase and decrease of the ridge, *Cimtaria* apparently becomes more curved dorsally with an explanate scooped out widening of its posterior end, *Mytilarca* becomes more acute umbonally, elongate, and compressed, the pterinoid genera show both increase and decrease of the wings, accentuation and softening of the surface sculpture, *Goniophora* becomes generally from the Schoharie, more expanded, with a less arcuate umbonal keel. *Pterinea flabella* found in the Upper Helderberg, but rare, is numerous in the Hamilton. It assumes a larger form with strong broad ribs in the Chemung, while around *Aviculopecten princeps* are grouped oscillations of related forms. *Panenka* and *Lunulicardium* were hardy genera surviving changed habitats.

The expansion of the Devonian lamellibranchiate fauna which seemed to begin in the Lower Helderberg was successively interrupted, and after each interruption widened its specific limits. Did the interruptions which expelled it to more restricted areas for development bring about the biological schock that caused the increase in species and a differentiation of new genera? It seems probable.

It is quite certain from the results of the Challenger expedition that the bothymetrical range of bivalves is most variable, as this compilation shows.

GENERA	DEPTH IN FATHOMS	GENERA	DEPTH IN FATHOMS
Martesia	49	**Astarte**	70-100
Teredo	1400	**Crassatella**	28-390
Gastrochaena	8	**Cardita**	10-60
Clavagella	7	**Carditella**	20-100
Solecutus	28	**Mytilus**	6-350
Saxicava	100-500	**Myrina**	1400
Mya	7	**Crenella**	140
Corbula	7-435	**Idas**	390
Anatina	18-28	**Modiolaria**	2-1675
Periploma	13	**Modiola**	15-800
Lyonsia	620-1950	**Perna**	10
Silenia	1950-2650	**Lithodomus**	6
Thracia	20-100	**Dacrydium**	100-390
Neaera	120-1950	**Modiolarca**	12-245
Poromya	155	**Septifer**	12
Pandora	7	**Julia**	40
Myodora	6-17	**Avicula**	8-30
Myochama	6	**Malleus**	3-12
Mactra	6-20	**Pinna**	38
Raeta	7	**Arca**	12-2000
Psammobia	6-70	**Trigonia**	2-38
Tellina	6-155	**Glomus**	390-1900
Donax	10	**Pectunculus**	7-1010
Semele	7-1000	**Limopsis**	28-1850
Ervilia	6-1000	**Nucula**	10-2050
Davila	20-150	**Nuculina**	15-20
Venus	3-1000	**Leda**	12-1675
Tapes	6-50	**Sarepta**	2385
Cytherea	7-70	**Yoldia**	28-345
Circe	2-435	**Malletia**	60-2550
Dosinia	6-25	**Pecten**	2-1375
Venerupis	70	**Lima**	2-2500
Petricola	8	**Amussium**	20-1675
Cardium	10-70	**Spondylus**	8-28
Callocardia	1000-2900	**Plicatula**	15-21
Chama	7-450	**Anomia**	50-350
Lucina	7-435	**Ostrea**	28
Tridacna	8		
Cryptodon	5-1900		
Diplodonta	6-150		
Kellia	28-38		
Montacuta	6-450		
Solemya	245		

If the Devonian lamellibranchs were expelled by the physical constants pertaining to the Marcellus and the Genessee or Portage, the expulsion of the Ammonoid fauna of the latter by the physical constants of the Hamilton and Chemung also excites comment. The Naples fauna, described by Dr. Clarke, is essentially cephalopdous, the Marcellus calcareous shales also contain a goniatitic fauna. There is an essential similarity in the fauna of the Marcellus and Genessee despite specific or generic contrasts and the diversity of those in the latter may be regarded as the result of changes induced in the former during some period of sequestration and absence. Where the Marcellus fauna disappeared to it is impossible at present to determine, but its reappearance as the Genessee is not an unnatural supposition. The lithological resemblance of the Marcellus and Genessee is striking and would seem to represent similar or identical sediments. The fauna in each is marked by cephalopodous features and while the lamellibranchs of the Marcellus which remained within it from the Upper Helderberg seas are absent in the Genessee, the brachiopodous occupants of both are unmistakably related, and the ichthyic fauna of both suggest still further a biological affinity or descent.

If the specific changes evinced in the Chemung bivalves are traceable to the confinement of the Hamilton in limited zones of development and changed environment, upon continental elevation and its (the fauna's) recession to the margins of the deeper seas, then it is logical to reverse the deduction in direction and find in the expanded (?) Genessee fauna a growth and change produced by the retreat of the Marcellus to the interior edges of the continent upon the invasion of the deeper waters of the Hamilton.

In basins, bays, and inundated half land-locked emarginations, the Marcellus sea-life, and especially its ammonoid contents, developed in congested centers, and prepared the new efflux of species and genera later preserved in the Genessee shales.

These suggestions point to the seeming efficacy of circumscribed areas in the development of the species; that a certain amount of biological pressure brings about interactions, perhaps not always referable to struggle or natural selection, which modify form and create species. And yet aside from natural selection what influence in the proximity of species or individuals could possibly differentiate them? Is not such an expression as "biological pressure" both ambiguous and childish? It might more properly be assumed that an excess of nutrition, perfect thermal conditions, purity of water, eradication or absence of enemies brought about the highest varitetal liveliness, and produced vigorous "sports" whose very vigor was an assurance of continued heredity.

The next extreme illustration of a ***biological crisis*** in the palaeozoic rocks is found in the crinoid-swarming seas of the Lower Carboniferous. The whole series of palaeozoic rocks afford nowhere such an extraordinary development of crinoidal forms, and while crinoidal limestones are frequent from the Calciferous upward, and establish the strong prevalence of these organisms, the actual predominence of the Lower Carboniferous fauna excluding cystids and blastids *in species*, is quite unmistakable.

A compilation from Miller's catalogue affords this striking comparison.

	Genera.	*Species.*
Paleozoic to top of Devonian..........	76	346
Lower Carboniferous	56	653

The same fecundity is shown in another way, by the greater number of genera marked by numerous species in the Lower Carboniferous over those excelling in species in the lower palaeozoics, while in none of the latter is there a comparable abundance to some of the more prolific genera of the Carboniferous seas. In the lower palaeozoics for instance, nine genera only have ten or more species assigned to them whereas in the Lower Carboniferous there are seventeen with *Actinocrinus* covering forty-seven species, ***Barycrinus*** twenty-three, *Batocrinus* fifty-two, *Cyathocrinus* thirty, ***Dichocrinus*** twenty-seven, *Dorycrinus* twenty-four, ***Eretmocrinus***, twenty, *Eupachycrinus* thirteen, ***Platycrinus*** sixty-seven, ***Poteriocrinus*** sixty, *Scaphiocrinus* sixty-two, *Taxocrinus* sixteen, and *Zeocrinus* twenty-nine.

In the lower palaeozoics ***Dendrocrinus*** has twenty-seven, *Eucalyptocrinus* twenty, *Megistocrinus* twelve, ***Poteriocrinus*** fifteen.

The impression of great numbers in the crinoidal life in the Lower Carboniferous is not relieved by any considerations of a defective geological record in the lower palaeozoics. There is no reason for suspecting that the record has been less carefully kept in the latter period than in the former. We are therefore met by a distinct organic profusion in the palæocrinoids at that geological epoch, and must infer that a conjunction of favorable circumstances and exuberant vitality in this phylum occurred at that time.

Dr. Carpenter in the "Voyage of the Challenger" has shown that while the stalked crinoids are partially abyssal they are not universally so, and if their abyssal habitat is to be interpreted as a retreat from shallower waters, we may be sure that the Lower Carboniferous seas were in no real sense abyssal. But it has been shown in the same work that the crinoids occur in groups, that if at any time they were continuously found over the sea that continuity is interrupted. There is a strong probability that in the Lower Carboniferous seas there was no geographical continuity of crinoidal life, but that a group of basins existed which were characterized each by its special faunal development, and had their origin somehow in the survival of those genera which existed in the early palæozoic, as *Agelacrinus, Calceocrinus, Cyathocrinus, Dorycrinus, Ichthyocrinus, Megistocrinus, Melocrinus, Platycrinus, Poteriocrinus, Synbathocrinus.*

And for this reason—the crinoids of the whole palæozoic are local, in distribution; they form segregated fossils. The expression of the group derived from their occurrence is sporadic, their habitat so to speak is concretionary. It can be accounted for by assuming that the character of the bottom is important in establishing their growth, that selection in this respect is decisive, and so, as the requisite foundations are limited, the crinoidal growth is limited and special.

In the Trenton, in New York, the *Caryocrinus* is found in small assemblages, and in the Cincinnatti beds *Iocrinus* and *Dendrocrinus* occur almost invariably in nests, groups, or bundles. In the Lower Helderberg *Mariacrinus* is also partial in its occurrence, and in the Waldron the *Eucalyptocrinus*, while more widely disseminated suggests colonies in its development. The *Megistocrinus* of the Upper Helderberg and Hamilton are uncommon, but when found are in bunches, and the large crinoidal stems in these formations seem crowded in localized areas.

The faunal basins we refer to in the Lower Carboniferous may have migrated, moved in and out, from the continent, up and down a coast line, but they became finally established in the Lower Carboniferous upon the most enduring basis, and in broader zones, and there developed their numerous specific and generic variations.

But assuming a great age for this development, the expression of *suddenness* is not unwarranted in referring to them. There is certainly slender suggestion in the Devonian of such large and opulent supplies of crinoidal life. The "biological crisis" they present is not simply apparent. It is real.

The crinoidal basins of the Lower Carboniferous illustrate again what is remarkable in the trilobites of the Cambrian, and the lamellibranchs of the Devonian, a great development of species in limited geographical areas. It is not one species from one locality, another from a second, and so on, but a convergence of species at one locality or province.

Amongst the possible elements of encouragement for the luxurious growth of crinoids in the waters of the Lower Carboniferous seas, was the clearness of the latter, and their greater supply of lime than in the waters of our present seas. The withdrawal of the crinoids today into abyssal regions, while not universal, is a prevalent tendency, and may have some reference to the increased sedimentation along coast lines. It may also be inferred that this abyssal retreat is not congenial to a flourishing life of crinoids, and their disappearance from our modern seas is certain.

The elevation of the Lower Carboniferous continent was probably low, the drainage to the coasts slow or inconsiderable, and it seems reasonable to suppose that the areas of very clear water approached the shores closer than they do today, offering an advantageous nidus for the development of crinoidal life. The successful planting of the ova when the stalk commences to form (pentacrinoidal stage) may be attended with dangers to the life of the young crinoid, which only clear water and peculiar bottom conditions can avert. As to the more rapid and easy assimilation of lime, the weight of the suggestion that the Lower Carboniferous seas contained more lime than those of today may be very slight. Yet it is quite easy to see that there is a difference in the assimilating functions of a Neocrinoid with its leathery tegminal crown, and that of a Palæocrinoid with its strongly plated calcareous dome, and that difference may have been brought about by some gradual decrease in the lime contents of the ocean.

(To be Continued.)

PREGLACIAL EROSION IN THE COURSE OF THE NIAGARA GORGE, AND ITS RELATION TO ESTIMATES OF POSTGLACIAL TIME.

By **Warren Upham**, St. Paul, Minn.

In the careful studies of the history of the Niagara river and gorge by Pohlman[*] and Gilbert,[†] as in the earlier observations of Lyell and Hall, the coincidence of the postglacial Niagara gorge with the preglacial St. David's channel at the Whirlpool is clearly recognized. The present river there has washed out the drift that filled the ancient channel and apparently reached to the bottom of the Whirlpool, about 130 feet above the sea. Thence the preglacial St. David's stream bed, beneath the drift, has probably this depth of 117 feet below the level of lake Ontario, or more, along its course past St. David's and onward to the deep central part of the lake Ontario basin.

The preglacial stream, as Pohlman has shown, drained the shallow Tonawanda valley, but not the area of lake Erie. At the Whirlpool this St. David's stream, according to Pohlman, plunged down in a cataract from the hard Medina sandstone bed, which is underlain and overlain by soft shales. Having at this place eroded a valley or ravine 400 feet deep and a quarter of a mile wide, the stream doubtless also had cut an important ravine, though of smaller size, along its higher course for a considerable distance before reaching the site of the Whirlpool. Dr. Pohlman supposes, with sufficient reasons, that the St. David's ravine reached along the part of the Niagara gorge occupied by the Whirlpool rapids, having a middle vertical fall over the Clinton limestone and terminating at an upper vertical fall over the Niagara limestone, beyond which, in its approach from the south, the stream was only a little lower than the adjoining country.

Some of the latest contributions to the geologic literature of Niagara, by Taylor, Hitchcock, and Gilbert, assign to the St. David's channel an interglacial age, and regard it as the

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[*] *Proc. Am. Ass. Adv. Sci.*, vol. xxxii, 1883, p. 202; vol. xxxv, 1886, pp. 221, 222. *Trans. Am. Inst. Mining Engineers*, vol. xvii, pp. 322-338, with maps and sections, Oct., 1888.

[†] Sixth Annual Report of the Commissioners of the State Reservation of Niagara, for the year 1889, pp. 61-84, with 8 plates (maps and sections); also in the Smithsonian Report for 1890. Monographs of the National Geographic Society, vol. i, pp. 203-236, with 21 figures in the text, Sept., 1895.

[illegible]

[illegible] valuable [illegible] Niagara Falls and [illegible] summarizing the [illegible] geologists, for the many visitors [illegible] and [illegible] Niagara during the present [illegible] and [illegible] my own former studies an- [illegible] Niagara [illegible] namely, that the erosion of [illegible] had been partly accomplished by [illegible] flowed along nearly the entire [illegible] of the gorge, after draining at its [illegible] nearly the same area as the present [illegible] channel at the Whirlpool

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[illegible] Geologist, vol. xxvii, pp. 375-377, June, 1901 this eastern tributary undoubtedly had cut a deep ravine, with falls and cascades, along its last mile or more. At the east end of the Foster flats and farther up stream, the preglacial Fish creek had only a very shallow valley, slightly hollowing but not trenching the bed rocks.

Under this view we see readily how the Niagara river withdrew its waters from the low cataract at the Foster flats. On reaching the head of the preglacial ravine in the gradual recession of the falls, the main current, which passed on the southeast side of the flats, speedily eroded a deeper channel, far below its former bed above that cataract, because the drift filling the old ravine was easily swept away. Along a distance of nearly two miles, adjoining the Foster flats and northeasterly, the river flowed afterwards in powerful rapids, eroding this part of the gorge into the rock strata to its present depth; and the greater depth, with slow and smooth current, for a half mile between the flats and the Whirlpool may be due to such deep erosion by the preglacial stream there, its ravine having been cut down nearly to the bottom of the St. David's channel before coming to their junction.

Evidently the preglacial brook that coincided somewhat nearly with the present Fish creek could not have passed northward through the Niagara escarpment in the course of the river gorge. The crest of the escarpment there is higher than the land stretching south and southwest to the Whirlpool. The gorge has no widening, such as is a most remarkable feature of the old channel at St. David's, where it approaches and cuts the escarpment; nor does it show evidence of much greater age there, as geologists count time, than along any other part, even near the present cataract. Prof. G. F. Wright has proved, instead, that the oldest part of the gorge, at and near the escarpment, can have endured the inevitable weathering of its cliffs no longer than 10,000 years, and that indeed its age, which is also the entire age of the Niagara river and falls, may be a considerably shorter period.*

Above the Whirlpool it seems very clear to my mind that the gorge erosion was much aided by the preglacial St. David's stream for the distance of one mile occupied by the

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*"New Method of Estimating the Age of Niagara Falls." *Popular Science Monthly*, vol. lv, pp. 145-154, with six figures in the text, June, 1899.

great floods. Here the greater part of the depth and width of the gorge had probably been already eroded before the Ice age, being then filled with drift, which the postglacial river easily removed as soon as its gorge toward Lewiston was sufficiently deepened. No powerful falls have there made a deep channel, and the river consequently has a [illegible] and very rapid course. Above the old St. David's [illegible], however, a massive waterfall has persisted along the whole distance of nearly five miles of the gorge, giving to the river there its great depth.

The action of a high waterfall with great volume of water precipitated over a hard stratum, of which large blocks give way and fall because they are gradually undermined, as in the Horseshoe or Canadian falls of Niagara, is well compared [illegible] to the deep wearing of potholes. The fallen blocks are moved under the powerful impact of the high cataract and wear a deep channel, attaining near the foot of the present falls the depth of almost 200 feet under the river level. Such cataract action of deep channel wearing may be also supposed to have produced the great depth, [illegible] feet, of the Niagara river at the mouth of the gorge; but I think that this is better attributed to the usual process of stream cutting at the time of depressed level of this part of Lake Ontario, which is otherwise known by its lower inclined beaches extending under the lake.

Among the conditions which might cause the Niagara river to vary from its present size, only one would produce a great and long continued diminution of the river, so giving for a large part of its history only very slow erosion of the gorge. This hypothetical factor in our problem, which has been assumed by Gilbert, Spencer, Taylor and Hitchcock, to [illegible] prolong the time of the gorge erosion, is the [illegible] of the outflow from the basins of the three lakes [illegible], then confluent and forming the glacial lake [illegible] its present course and passage eastward [illegible] the way of Lake Simcoe and the [illegible], and later by Lake Nipissing and [illegible] Ottawa.

[illegible] elevation of the land from its Late Glacial [illegible] depression took place here, as for the area of lake Agassiz, as soon as the land was unburdened by the glacial retreat. This northward uplift was in progress while yet the ice barrier remained farther north and northeast, holding in succession the glacial lakes Warren and Algonquin, besides several earlier and smaller glacial lakes which became merged in lake Warren, on the upper part of the St. Lawrence basin. In the areas of lake Agassiz and of the Laurentian lakes alike, the uplift was nearly completed during the existence of the glacial lakes, as is known by the almost undisturbed horizontality of the latest and lowest glacial lake beaches. Finally lake Algonquin, by the northeastward land elevation, became divided into its successors, lakes Huron, Michigan, and Superior.

Instead of the hypothesis of long continued eastward outflow from lake Algonquin, my studies convince me that the Trent and Mattawa outlets were occupied successively during only a brief time, or, more probably, that these outlets were obstructed by the receding ice-front until after the land there had risen from its Champlain depression to such altitude that the St. Clair and Detroit rivers continued to be constantly the outlet from the upper lake basins, sending their waters to the Niagara river and falls during all their history. Lakes Algonquin and Iroquois were contemporaneous, and the Ontario basin inclosing lake Iroquois was at the same time uplifted toward the northeast, with inclination of its earlier shorelines, and with gradual rise of the lake on the land westward because its outlet at Rome, N. Y., was raised much more than the western part of the basin. While these two glacial lakes were undergoing such changes, a lobe of the mainly retreating but wavering ice-sheet lingered on the highlands north of lake Ontario; and twice its moderate readvance was recorded by deposits of till intercalated with the stratified beds of a lacustrine delta in the extensive section of Scarboro Heights near Toronto. The uplift of the Iroquois basin as well as that of the Algonquin basin, is thus shown to have been far advanced and nearly completed during the continuance of their ice barriers.

Latest, the glacial lake St. Lawrence, held by the final blockade of the waning ice-sheet on the St. Lawrence valley below Montreal, extended into the lake Ontario basin with a [illegible] of about [illegible] feet above the Thousand Islands, but was [illegible] water level beneath the present surface of the west part of this lake. In like manner with the earlier lake Iroquois the progressing northeastward uplift caused the level of the lake St. Lawrence and afterward of lake Ontario to rise upon the land in the southwest part of the Ontario basin. It was during these late stages of the lacustrine history of this region that the deep channel of the Niagara river at the mouth of its gorge was eroded, the channel being subsequently partially refilled with water by the continuance of the northeastward land elevation. The river from Lewiston north to its mouth has a depth of 100 to 200 feet, which indicates almost as much rise of this part of lake Ontario, for no high waterfall existed to erode the very deep channel there.

The vast country which had been ice-covered and depressed under the weight of the thick continental ice-sheet was gradually uplifted, and to a greater hight at the north than at the south, during the removal of the ice burden. While lakes Agassiz and Warren still existed the northern parts of their areas were raised, in comparison with their southern outlets, 300 to 400 feet or more. It is also found, by the present inclinations and relationship of the successively formed shorelines of these and the other associated glacial lakes, that this epeirogenic movement proceeded as a permanent wave of land elevation from the periphery of the old ice-sheet inward to its central area.

Accurate maps of the crest line of the falls were made by Hall in 1842, by the U. S. Lake Survey in 1875, by Woodward in 1886, and by Kibbe in 1890. It is thus ascertained that in the forty-eight years following the first survey the lengthening of the gorge, by the recession of the central part of the Horseshoe fall, was 270 feet, the average rate being about five and a half feet yearly. But the central curve or apex of the cataract is worn back much faster than its sides, because the river has its maximum depth of fully twenty feet at its center and there makes a plunge of not merely the 160 feet from the verge to the surface of the water at the foot of the fall, but of nearly 200 feet lower to the bottom of the river, working thus most effectively to undermine the horizontal rock strata and break down the thick limestone at the top.

The entire extent of the Horseshoe fall is found by these surveys to be worn away at an average rate of about two feet yearly; but during the four years from 1886 to 1890 the average annual rate of erosion for the whole was five feet. Along the more shallow American fall, northeast of Goat island, the mean yearly erosion is about two-thirds of a foot, but from 1886 to 1890 it averaged one and two-thirds feet. The energy of this part of the Niagara cataract is not sufficient to remove its huge fallen blocks of limestone, on which the water strikes along all the base of the precipice.

Only the center of the Horseshoe fall plunges deeply into the river beneath, and its concentrated and intensified erosion tends at present to lengthen the gorge beyond its normal rate, which appears probably to be about three or four feet yearly. With such average erosion, the recession of the falls and prolongation of the gorge would amount to one mile in about 1,500 years; and the action of the great cataract along the two miles of deep water south of the railway bridges would have begun about a thousand years before the Christian era. The entire erosion of the six and a half miles of gorge between Lewiston and the present falls would require about 10,000 years, excepting that this period would be diminished probably about a third, to 7,000 years, more or less, by the preglacial erosion of the St. David's stream and its northeastern tributary.

In 1841 Sir Charles Lyell estimated the rate of lengthening of the gorge to be about a foot yearly, and its age therefore about 35,000 years. Gilbert, at the Buffalo meeting of the American Association for the Advancement of Science in 1886, comparing the exact surveys, estimated the recent rate of recession of the falls to be about five feet yearly, giving, if this were the average for the whole gorge, about 7,000 years for its erosion. Pohlman, in 1888, considered the recent recession to be at the rate of a mile in 2,000 years; but the whole period, as he first showed, was much diminished on account of the preglacial erosion. Later, in consideration of a supposed loss of the outflow of the upper great lakes, leaving to the Niagara river, during a very long time, only a small part of its former and its present volume of water, the age of the river and gorge has been computed by Spencer as 32,000 years;[*] by Taylor, about 50,000 years;[†] and by Hitchcock, about 19,000 years.[‡] Wright, from a different and independent computation, based on the subaerial erosion and widening of the gorge in its most ancient northern part, concludes, as before noted, that its age is no more than 10,000 years.

But there are, as this discussion has also before noted, ample reasons for distrusting the arguments and computations of Spencer and others concerning eastward outlets from the upper lakes, subtracting their flow from the Niagara river, which, as I believe, are untenable, or, at the most had only a very short existence. Omitting that element of the problem as insignificant, we have approximately 7,000 years, according to the diverse but concurrent computations, for the probable time occupied in the erosion of the gorge.

Not satisfied with thus rejecting the hypothesis of long and great subtraction from the water supply of Niagara, I wish to direct attention to a very important cause of great increase of size of the river and falls at the beginning of the gorge erosion. The discharge of the river during the last 1,000 years may be approximately represented by 1,200 or 1,500 feet of water covering all the upper St. Lawrence drainage basin above these falls. This average water supply I believe to have been doubled or trebled during the first 1,000 years of the river history by the added flow derived from the final melting of the ice-sheet, mostly 3,000 to 5,000 feet or more in depth, upon a very large region stretching from lakes Huron and Superior far north and northwest. For some part of this time the Niagara river probably received the outflow from the basin of the glacial lake Agassiz, that is, the vast central tract of Canada between James bay and the Rocky mountains.[§] Within its first 1,000 years, therefore, the more powerful Niagara may have accomplished about half of its gorge erosion between Lewiston and the Whirlpool. When the river was reduced to its present size, after its tributary ice melting ceased, 2,000 years were probably adequate for the completion of the gorge to the Whirlpool, the work having been greatly lessened by preglacial erosion. Similarly, on account of the old St. David's ravine, 1,000 years, or less, would suffice for the erosion along the Whirlpool rapids. Afterward, under the present conditions of gorge lengthening, 3,000 years were needed for the last two miles, next to the present falls. The whole history would thus comprise about 7,000 years.

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[*] AM. GEOLOGIST, vol. xiv, pp. 289-301, Nov., 1894; *Am. Jour. Sci.*, third series, vol. xlviii, pp. 455-472, Dec., 1894; Eleventh Annual Report of the Commissioners of the State Reservation at Niagara, for the year 1894, pp. 99-117, with maps, sections, and views from photographs.

[†] *Bulletin, Geol. Soc. Am.*, vol. ix, pp. 59-84, with two maps, Jan., 1898.

[‡] *Am. Antiquarian*, vol. xxiii, pp. 1-24, with maps and views, Jan. and Feb., 1901.

[§] "The Glacial Lake Agassiz," Monograph xxv, *U. S. Geol. Survey*, 1895, 7-244.

This measure, which (not to be too exact in figures depending on the many varying conditions of the Niagara history) we may place in round numbers as between 5,000 and 10,000 years, is at the same time the duration of the period since the end of the Ice age, or, speaking more definitely, since the retreat of the continental glacier from the northern United States and Canada. It may be accepted with confidence, for it agrees with the estimates and computations independently made for the same period by Prof. N. H. Winchell, from the recession of the falls of St. Anthony; by Dr. Andrews, and recently also by Leverett, from the shore erosion of lake Michigan and the accumulation of sand at its south end; by Wright, from the filling of depressions among kames and eskers, and from erosion by streams tributary to lake Erie; and by Prof. B. K. Emerson, from postglacial deposition in the valley of the Connecticut river. In Europe, likewise, numerous estimates of the lapse of time since the Glacial period, as collated by Hansen, are found to be comprised between the limits of 5,000 and 12,000 years, being thus well harmonious with the measure given us by Niagara falls.

In accordance with the ratios of the relative duration of preceding geologic periods and eras, having now found the approximate measure of the latest term in the series, namely, this Postglacial period, as about 7,000 years, we may well estimate the whole Quaternary era, including the Ice age, as about twenty times longer, giving to this era some 150,000 years. The Tertiary era, with erosion of the stupendous Colorado cañon and baseleveling of the plains between the Red River of the North and the Rocky mountains, appears by the changes of its marine molluscan faunas to have been vastly longer, having comprised probably three to five million years; and the very long preceding eras since life began on the earth may have included, as estimated by Dana, Walcott, and others, about one hundred or two hundred million years.

If a much longer time than the 7,000 years estimated in this paper should be admitted for the duration of the Niagara river and the Postglacial period, as Spencer and Taylor suppose, all the terms of this geologic series making up the age of the earth must be proportionally multiplied five-fold or seven-fold. The whole would then pass far beyond the maximum limit which seems to have been reliably determined by the researches of geology, astronomy, and physics.

NOTE ON CERTAIN COPPER MINERALS.[*]

By Alexander N. Winchell, Butte, Montana.

Chalcopyrite has been noted more than once as an accidental product in metallurgical operations. Thus, Hausmann[†] described it as resulting from imperfect roasting of copper bearing ore at the works in Goslar and in Ocker. The mineral was here found in crystals exceeding five millimetres in largest diameter, twinned and striated: the crystals were of a fine black color, and a little altered on the surface.

Plattner[‡] noted similar crystals in a crack in the bed of a reverberatory furnace at Mulden near Freiberg. These crystals contained, according to analysis, a slight excess of iron, and small amounts of foreign metals.

So far as known to the writer bornite has never been described as an accidental furnace product, nor as produced artifically by sublimation. Its reproduction has been accomplished only by fusion, or by the action of thermal springs upon bronze.

It is intended here to describe an occurrence of chalcopyrite and bornite at the smelter of the Butte & Boston Consolidated Mining Co., at Butte, Montana. The minerals form slowly, attaining their maximum thickness of about four inches in the course of six months to a year. They form in the Allen-

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[*] Read at the Denver meeting of the American Association for the Advancement of Science, August, 1901.

[†] Hausmann:—*Goett. gelehrt. Nachr.*, 1852, No. 2, p. 177, Ref. from Encyc. Chimique. Bourgeois:—Reproduction artificielle des mineraux, p. 45.

[‡] Fuchs:—*Die kunst. darg. Min.*, p. 62, ref. from same source.

O'Harra calciner along the rails in the bed of the furnace. In fact, they not only form beneath the flanges of the rails, but also slowly replace the rails themselves. This replacement continues to such an extent that finally, when the rails are taken out, they have only a thin upper surface layer of iron; all the rest has been transformed into chalcopyrite and bornite, with the exception of that portion of the rails completely embedded in the brick bed of the furnace. Furthermore, the replacement is so gradual that it is impossible to distinguish any exact line of demarcation between the remaining iron of the rail and the mineral sulphides.

An examination of these sulphides shows that, while they are somewhat impure from mechanically admixed quartz and perhaps some other foreign matter, they exhibit the true characters of chalcopyrite coated in places with films of bornite, occasionally of appreciable thickness. Thus, the former mineral has an uneven fracture, a hardness less than 4, a brass yellow color, and a greenish streak. The specific gravity is considerablv decreased by foreign matter present, being only about 3.8. The mineral occurs both finely and coarsely crystalline, and these varieties pass abruptly into each other. In a small lenticular cavity several crystals were found, which attained only about one-fourth of a millimeter as a maximum diameter. They were nearly all tarnished by a coating of bornite, but a few retain a brass yellow color. They present the tetahedral aspect predominatingly; some seem to be mere triangular tablets. Twinning occurs, apparently parallel to (111), and striations are abundant.

The massive mineral was subjected to partial analysis. The copper was determined by means of the potassium cyanide method, the iron being filtered off and weighed after the titration was nearly completed. The powdered mineral was treated with boiling nitric acid for about half an hour, and it is therefore possible that small amounts of silica and alumina are included in the iron percentages; the sulphur was determined by the ordinary barium sulphate method. The analysis was carried out in the mineralogical laboratory of the Montana State School of Mines on material presented to the school by Mr. John Gillie, superintendent of the Butte & Boston Consolidated Mining Co.

	I.	Ia.	II.	IIa.	III.	IV.	V.
Cu............	25.63	28.95	25.15	28.00	34.5	15.8	27.54
Fe............	34.51	38.97	35.79	39.86	30.5	39.4	38.80
S..............	28.40	32.08	28.85	32.14	35.0	29.0	30.07
SiO_2.........	8.62	....	9.20	....	....	9.2	3.45
Total........	97.16	100.00	98.99	100.00	100.0	93.4	99.86

I. Chalcopyrite from Allen-O'Harra calciner of the Butte & Boston smelter, Butte, Montana. No zinc nor nickel. A. N. Winchell, analyst.

Ia. Same recalculated, omitting SiO_2.

II. Calcopyrite from Allen-O'Harra calciner of the Butte & Boston smelter, Butte, Montana. No zinc nor nickel. A. N. Winchell, analyst.

IIa. Same recalculated, omitting SiO_2.

III. Theoretical composition of chalcopyrite.

IV. Chalcopyrite from Allen-O'Hara calciner, Butte & Boston smelter, Butte, Montana. 10 oz. Ag. Mr. Steele, assayer for the Co., analyst.

V. Chalcopyrite from Castellina Maret., Italy. C. Bechi, analyst. *Amer. Jour. Sc.*, 1852, xiv, p. 61.

The similarity between the analyses of the artificial chalcopyrite and the natural mineral analyzed by Bechi is striking. It is to be noted, further, that the crystals analyzed by Plattner contained a slight excess of iron, as does the mineral here described.

The bornite does not occur in sufficient amount to permit of analysis, but its identity is established by the presence of the irridescent colors peculiar to it. The blue and red colors on different faces are abundant; and these colors are also modified by the yellow of the chalcopyrite.

Both the chalcopyrite and the bornite have been formed by sublimation, and not by fusion, since the temperature of the furnace never rises high enough to fuse the ores present.

Summarizing, we have here another example of chalcopyrite as a furnace product; in this case it is formed by sublimation; and, as it forms, it replaces and destroys the iron rails of the calciner. Further, we have the formation of bornite in small amounts by sublimation under the same conditions which lead to the formation of chalcopyrite in much larger amounts.

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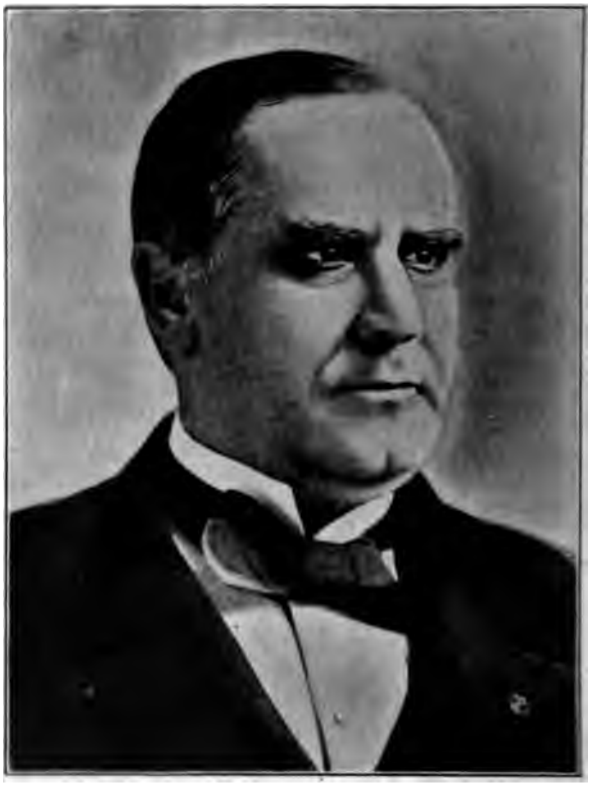

WILLIAM McKINLEY;
Late President of the United States of America.

THE AMERICAN GEOLOGIST,
VOL. XXVIII. PLATE XXII.

EDITORIAL COMMENT.

EDWARD WALLER CLAYPOLE.

Prof. E. W. Claypole, one of the charter members of the Geological Publishing Company, died at Long Beach, California, Aug. 17. He had been complaining of a "nervous trouble," as he termed it, for some time. It had settled in his left hand and his right foot, and hampered him so that he could not get about as he had been used to do. In a recent letter to the writer he remarked that he had had the most harassing year of his life, resulting from the sickness of Mrs. Claypole and his own disability. His trouble culminated in a sudden rheumatic attack at the heart whch brought on unconsciousness which continued until his death, two days later, at sixty-six years of age.

Born in England he adopted America, but with a lingering love for his boyhood's hearthstone, which caused him to revert affectionately to the associations and institutions of his native land. He was well known in England as a geologist prior to his coming to the United States, and several of his scientific contributions written since have also been published in England.

His was a retiring, scientific temper and turn of mind and manner. He disliked the heat of any dispute, and rarely mixed in any fray. His even tenor of mind was displayed in the character of all hs papers. He seemed to think the power of truth was so great that it required only a plain and simple statement to make it invincible, however its acceptance might be delayed by error and misrepresentation. In a quiet way however, he was unswerving from what he considered right, and would return to the same, when opposed, from different points of view, though never with direct contradiction of his opponent. In that he always displayed the highest type of mental civility.

His services to geological science were numerous and highly important, and will be noted more in detail in a future number of the GEOLEGIST, to which he was a frequent contributor.

The scope of his studies, and of his writings, was broad. As a scientist he belonged to the old school, to which belonged most of the geologists of fifty years ago. He did not content himself with specialization in any line, but participated in physics, paleontology, glacial geology, prehistoric anthropology, and in all general geology, biology and botany.

He was educated at the University of London from which he received the degrees of B. A. and D. S. He was professor of Natural Science at Antioch College, Ohio, 1873 to 1881; paleontologist to the Second Geological Survey of Pennsylvania, professor of Natural Science at Buchtel college, Akron, Ohio, from 1883 to the time of his removal to Pasadena (1898) where he was professor of biology and geology in the Throop Polytechnic Institute till the time of his death He was a fellow of the Geological Societies of London, Edinburgh and America, and of the American Association for the Advancement of Science. He was greatly beloved and revered by his pupils and by all others with whom he came into contact. In the highest sense he was one of humanity's natural noblemen.

N. H. W.

THE ORIGIN OF AUSTRALIAN IRON ORES.

A recent publication by the Department of Mines and Agriculture of New South Wales[*] contains a valuable contribution to the origin of iron ores. Recognizing various conditions and origins of iron ores as given by the author, the writer refers here especially to the aluminous iron ores and bauxites of Wingello. It is important that like some others Mr. Jacquet associates bauxite and hematite in a common discussion and assigns to them an identical origin, viz. a change from igneous rock, generally basalt. No such associated origin has been ascribed to the bauxite deposits of the United States. The intimate connection of the pisolitic iron ore with basalt in New South Wales appears to have been noted by C. S. Wilkinson in 1872, and later by Mr. T. W. E. David. Mr. David says: "This formation has a superficial area of eleven square miles, five hundred and seventy-seven acres, and a thickness of from a few feet to forty feet. These beds at the surface consist of red dusty soil, passing downwards into red, yellow or gray tuffs and compact pisolitic ironstone, which in turn graduates into rotten spongy basalt." * * * As specimens of the rock vary considerably in structure and composition the term laterite must be taken to have rather a wide application. While some of the specimens are clearly tuffs, others show little trace of eruptive origin, and may be described as earthy pisolitic ironstone, more allied to a sedimentary formation than a volcanic. * * * The probable explanation of these facts appears to be that the greater part of the laterite is an altered basalt tuff belonging to the earlier basalt eruptions of the Eocene period." In 1899 Mr. Jacquet reported that the pisolitic ironstone near Wingello contains free alumina, and is a variety of bauxite. Since that date samples have been chemically tested from many allied deposits, and the results show that ferruginous bauxite is distributed over a considerable area of the colony. This ore is of Tertiary age, as evinced by fossil-bearing strata associated with it. These strata are sometimes overlain by basalt.

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[*] *Memoirs of the Geological Survey of New South Wales. Geology No. 2.* The Iron Ore Deposits of New South Wales. J. B. JAQUET, Sydney, 1901.

The ore is composed of rounded grains of concentric structure, and varying in size from two millimeters in diameter to eight centimeters. Two analyses showed respectively alumina thirty-four and thirty-two per cent. and iron (Fe_2O_3) twenty-nine and forty-four per cent; also 4.45 and 4.70 per cent of titanic acid. The former analysis was of an oxidized sample, and the latter, in each case, of an unaltered primary ore. "The second analysis seems to indicate that the primary ore consists essentially of a mixture of ilmenite and ferruginous bauxite."

The author concludes that not only this but probably many other deposits of bauxite and aluminous ores elsewhere in the world have been derived from alteration of basalt; although in some cases not from alteration *in situ* but from the distributive action of water in shallow lakes or rivers in Tertiary time,

Mr. Jacquet calls attention to the somewhat similar iron ores of the Clealum river in Washington which have been described by Mr. J. P. Kimball,[*] and by Messrs. Smith and Willis, and which contain free alumina and may perhaps be designated ferruginous bauxites. Messrs. Smith and Willis[†] state: "The Clealum ore resembles in a general way some of the more ferruginous bauxite ores, and, as has been seen, it also occurs with the same relations to a basic rock that the German bauxites show to basalt."

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[*] AMERICAN GEOLOGIST, 1898, xxi, pp. 161-163.

[†] *Trans. Am. Inst. Min. Eng.*, February, 1900.

In another chapter the author describes "basaltic iron ore," i. e. such that is derived undoubtedly during the process of weathering from basalt. This he considers an additional link in the evidence which goes to prove that aluminous iron ores may have a residual origin from basalt.

The writer considers the report and conclusions of Mr. Jacquet as contributory evidence of the truth of his hypothesis of the derivation of the Mesabi iron ore which is also sometimes distinctly pisolitic, from basic volcanic sand gathered on the beach of the Tacomic ocean and accumulated in greater thicknesses in the adjacent shallow waters. N. H. W.

THE ANTIQUITY OF THE RACES OF MANKIND.

In view of the latest discussions bearing on this question, by Howorth in the August number of the *Geological Magazine*, and by McGee and others at the Denver meeting of the American Association, it seems timely to note here some of the geologic evidences of the great antiquity of man, and to consider the origin of his principal races, commonly called white, yellow, red, and black.

Among the numerous localities in the northern United States where traces of man's presence during the closing part of the Ice age have been found, is one in Gaines, Orleans county, N. Y., about fifty miles east-northeast from Niagara Falls. A prehistoric hearth was here encountered in digging a well, at the depth of fifteen to eighteen feet below the surface, being at the base of the beach ridge of gravel and sand which marks the highest southern shore of the glacial lake Iroquois, about 175 feet above lake Ontario (G. K. Gilbert, in the *American Anthropologist*, vol. ii, pp. 173, 174, April, 1889). Charred sticks, with ashes, and three boulders laid to inclose the fireplace, there attested man's abode, or a transient hunting expedition, at the time when the front of the receding ice-sheet yet rested on the adjacent part of Canada close north of Toronto, and on the Adirondacks and the St. Lawrence valley, turning the outflow of lake Iroquois to the Mohawk and Hudson rivers. The Niagara had just begun to cut its gorge; from which the subsequent lapse of time is computed to have been about 7,000 years.

Evidences of man in somewhat earlier stages of the general decline of the Ice age are found in the Trenton gravels of the Delaware valley, in similar valley deposits of Ohio, and in the modified drift of the Mississippi valley at Little Falls, Minnesota. Much older geologic testimony of primitive man has been obtained in Idaho and California, carrying the record back to a period probably preceding the Ice age, but within the Quaternary era. It is certainly our duty, however, as urged by Holmes, to accept such testimony only when it is very clear and reliable.

Geologic archæology in Europe rests on a firmer basis of ample observations, indubitably demonstrating man's existence there before the culmination of the Glacial period, and indeed, I think, before its beginning. From my examination of the implement-bearing gravel deposits of the Somme valley in northern France, where the proofs of man's great geologic antiquity were first recognized and published, I conclude that Paleolithic men began their occupation of that country before the epoch of great elevation of the lands which became glaciated, probably contemporaneously, in both Europe and North America (AMERICAN GEOLOGIST, vol. xxii, pp. 350-363, Dec., 1898). This conclusion, affirming the vast antiquity of mankind, but admitting many differences of views as to the history of the Quaternary era and formation of the drift, is believed by Howorth to be shared by the majority of European geologists.

The origin of the great races of mankind, namely, the Caucasian or white race, the Ethiopic or black race, the Mongolic or yellow race, and the American or red race, seems probably to have been the result of many thousands of years under the influences of climate, food, and other conditions of life, in the several great continental regions inhabited by these races, to which mankind had previously become dispersed. The beginning of the human epoch, when our species gained such development of body and mind as to deserve its generic and specific name, *Homo sapiens,* we cannot well designate more clearly than to say that it far antedated the close of the Ice age. It was undoubtedly several times more ancient than the western Aryan migrations, which, by their relations to the waning European ice-sheet, appear to have occurred some 5,000 to 10,000 years ago. According to my studies as a glacialist, it seems to me that Flinders Petrie has given as satisfactory estimates as can be made with our present knowledge, in his recent suggestions assigning 100,000 years as the probable duration since Paleolithic man appeared in the Somme valley, and 10,000 years since Neolithic man came into western Europe. Eolithic man, known by his very rude stone implements in stream deposits which are preserved on high plateaus in southern England, belonged doubtless to a time considerably earlier than 100,000 years ago; so that we may perhaps allot twice that period for the existence of man and the development of his principal races.

All mankind, however, constitute only a single species. A requisite condition of distinctness separating species is the inability to produce hybrid offspring, or, when such offspring is possible to nearly allied species, it is incapable of reproduction. Judged by this essential part of the definition of every zoologic or botanic species, the whole human family is specifically a zoologic unit. All its races and varieties are freely fertile with each other. However different in color, stature, features, mental attainment, or all other qualities which distinguish races and nations, they blend together. Such intermingling, mostly of the black and yellow races, has apparently been the origin of the Malay, Australian, and Polynesian peoples. In America, on the contrary, no considerable foreign intermixture seems to have occurred since the very early time when this continent was first peopled. The immigration came probably from northeastern Asia, across Bering strait, and perhaps in part also, at nearly the same time, from Europe, over a land connection by the Faeroe islands, Iceland, and Greenland.

An objection to such migrations of primitive man during the Glacial period may be based on the ice-covered condition of North America at that time, wholly enveloped by an ice-sheet upon its northern half, northward from the Ohio, Missouri, and Columbia rivers, excepting the greater part of Alaska. If the preglacial and early Glacial altitude of the continent had been the same as now, this objection would be valid, and we should be obliged to refer these ancient migrations wholly to a time before the accumulation of the North American ice-sheet, which reached both east and west beyond the present coast lines. But it has been ascertained that this northern part of our continent was then elevated 3,000 to 5,000 feet higher than now. During the epoch of ice accumulation and culmination, its boundaries probably failed to reach generally to the coast line of that time. Along the sea border, where food supplies such as savages rely upon are most easily obtained, preglacial and Glacial man may have freely advanced on a land margin skirting the inland ice, as along the present borders of Greenland. It was only in the Champlain epoch, closing the Glacial period, that the ice-burdened lands sank to their present altitude or lower, bringing the edges of the ice-sheet beneath the encroaching sea.

The many divergent branches of the American peoples and their remarkable progress toward civilization in Mexico, Central America, and Peru, before the discovery by Columbus, indicate for this division of mankind probably almost as great antiquity as in the eastern hemisphere. Although we are unable to define the date, in thousands of years of antiquity, when the American race came into its heritage, we may paradoxically say that it came here before it had been differentiated from the primordial stock of mankind so as to be racially distinct.

Processes of change, whether of progress or of regression and sometimes extinction, are now taking place and are modifying species and races perhaps as fast as during any former period in the history of our globe. We see allied varieties or races of plants and animals, living intermingled in the same district, or more frequently in different but adjoining regions, or sometimes quite separated geographically, which are not yet sufficiently distinct to rank as separate species, but which seem surely destined to diverge more, until their increasing difference and decreasing affinity shall give them that more distant relationship. The parent stock and the diverging branches are all the while represented by multitudes of individuals. Divergent species and races, therefore, have come into their present strongly contrasted characters from preceding ancestry which was a unity in its specific character, but which resembled any vigorous species of the present time in comprising a vast number of individuals occupying a somewhat extensive geographic area.

The Creator, working through long ages by these processes of descent with modification, which we call evolution, has developed the great races of mankind from some single older and much different ancestral species of less intelligence. Anthropology, the science of the development of man and his races and tribes, agrees thus with the words of the inspired apostle Paul, in his address to the Athenians, teaching them of God who "made of one blood all nations of men to dwell on all the face of the earth." W. U.

REVIEW OF RECENT GEOLOGICAL LITERATURE.

The New Basis of Geography. By J. Q. REDWAY. The Macmillan Co. Pp. 229. Price $1.00.

This book, which is written primarily as a manual for teachers of geography, will be of interest to the wider circle of students of geography. The new geography, to quote the preface, is "the mutual relation of geographic environment to political history on the one hand and economic development on the other." The first half of the book deals with this subject of geographic environment. After considering the influence of environment on man's historical development, the writer takes up various incidental influences of topography on life and concludes this part of the book with a very interesting chapter on the effects of topography and climate on the economic history of the United States. In a book of this compass the treatment must be suggestive and elementary, rather than exhaustive.

The second half of the book is of more strictly pedagogical interest, and deals with aims and methods of geographic teaching in the elementary and secondary schools. Many of the suggestions will prove helpful to teachers of physical geography and geology in secondary schools.

It is a pleasure to get hold of a work in which the writer has something to say, knows what it is, and then goes on to say it in a clear, incisive and attractive manner, so much of our geological and geographical writing is done in other lines. L. G. W.

Paleozoic Faunas of Northern Arkansas; by H. S. WILLIAMS. (Arkansas Geol. Sur., Ann. Rept. 1892, pp. 268-362, 1901.)

Probably no region of its size has had so much geological investigation carried on within its borders, and at the same time had so little accomplished regarding the geological age of the various formations, as the Ozark highlands. What has been needed most has been exact paleontological data. It is therefore an exceptional pleasure to see the recently issued chapter on the Paleozoic Faunas of Northern Arkansas.

Professor Willams' notes are the outcome of much labor in the field by many individuals, extending over more than a decade.

Concerning the general problem presented, professor Williams says: "On account of the apparent conflict between the interpretation of the stratigraphy made by the field observers and the interpretation suggested by my study of the fossils, I went to Arkansas in August, 1890, and traversed the ground with Dr. Branner, confirming the fact of sudden and great change in the paleontological horizons, in several places where the lithological characters of the rocks and the stratigraphy little and often obscure evidence of facts. Although our examination was rapid and very few additional fossils were accumulated, the great importance of the Devonian interval, as it may be called, was clearly established. The course traversed was from Batesville westward, across country, to Eureka Springs. The best expression of the details of the interval were seen at St. Joe, where, without apparent unconformity of strata, the Silurian limestone is separated by a few feet of green shale and nodular sandstone, called Sylamore sandstone, from the Carboniferous limestone."

The geological formations are assigned ages as follows:

Carboniferous.	Genevieve or Boston group. Batesville sandstone. Spring Creek black shales. Cherty beds (Boone.chert). Carrollton limestone. St. Joe marble. Eureka shale (typical).
Devonian.	Sylamore sandstone. Eureka shale (in part).
Silurian.	St. Clair limestone.
Ordovician.	Polk Bayou limestone. Izard limestone. Saccharoidal sandstone. Calciferous, or Magnesian, limestone.

The faunas of the several formations are then indicated and briefly discussed. Among the noteworthy features brought out, none is of greater significance than the determination of the dual character of the great limestone which the Arkansas field geologists had long called the St. Clair limestone. One part carries a typical Ordovician fauna, while the other contains Silurian fossils. The distinction is especially important from an economic standpoint. The manganese deposits of the state are found on the horizon which separates the two parts of this limestone, whenever the two are present in the same section. "Whenever the manganese is present it is always above or at the top of the Polk Bayou limestone of the section. The evidence is conclusive, therefore, that the erosion, causing the interval, was after the deposit of the Polk Bayou limestone, and the evidence of the few fossils in the Cason shale indicates that the manganese-containing deposit was made at an age closely corresponding to the Clinton of the New York sections, and was incident to the deepening seas which soon after received the limestone formation of the St. Clair (Niagara) epoch.

The Devonian of the Ozark region has always been a puzzle to geologists. Professor Williams' observations go a long ways in solving some of the most perplexing phases. "In numerous places in north Arkansas the evidences of an unconformity separating the Silurian from the overlying Carboniferous, are very clear. In some cases there is no rock-material separating these two grand terranes. In other cases there are greenish shales, or coarse sandstones, with polished grains and rounded nodules of black shale; and in the western section the interval is occupied, in part, by a black shale, the Eureka shale of the Washington County report." The fauna in the fine shales which succeed the black shales is correlated with that of the Louisiana or lithographic limestone, and "is thus as late as the Kinderhook stage of the Eocarboniferous."

The interpretation of the facts is "that the typical interval-materials, the green shale and the Sylamore sandstone, were deposited after the period of the formation of the typical black shales which, along the borders of the Ozark uplift, was terminated, or actually driven outward, by the elevation of that region; that these particular deposits mark the stage of sinking again of the land and the resultant erosion which introduced the Carboniferous formations for this region; that the time was at the very close of the Devonian and beginning of the Carboniferous eras. I conclude that the explanation of the varying age and nature of these deposits is due to the sections having been taken at places at lower or higher position on the gradually sinking land and expressing the overlap of the successively more recent deposits. Further study of the whole problem of the deposits filling the Devonian interval in the South has led to the conclusion that, however much erosion of the underlying Silurian formation took place, the sediments of black mud forming the shale did not begin till after the beginning of the Devonian era. The age of the beginning of the new sedimentation being determined by the first deposit above the abrupt change, the unconformity may not be indicated by conspicuous modification of the plane of sedimentation. We should less expect real unconformity in the central part of the continental mass as in the Mississippi valley region than in the borders where the folding and faulting has been chiefly concentrated."

There is one statement concerning the Carboniferous which deserves more than passing notice. It relates to the Spring Creek [illegible] which may be the equivalent in part of the Fayetteville shale of the western part of the state. It is of interest to note the [illegible] between the shale and decided change of fauna and the [illegible] change of the rocks. The passage beginning with the [illegible] argillaceous shales through calcareous and [illegible] of cherty limestone, becoming more and more cherty [illegible] the top. Then comes a sudden change; black shales, and black sheets of limestone, with silicious sand mixed with them; sometimes beds of sandstone; but the order is various and different in separate sections a few miles apart.

"It was in this black shale and limestone, with more or less sandstone, that the new fauna arrived; in the present case, a remarkable fauna for the locality. It included species which have never been seen before in the Mississippi valley, but are known in Nevada. It includes species which were never known before to occur so late in the series, but are common types in the preceding Devonian. The fauna points to some change by which communication was made with distant localities in the, then, sea basin." On the whole the Paleozoic faunas of northern Arkansas may be said to be the most notable contribution to our knowledge of the Ozarks that has ever been made. C. R. K.

What is an Echinoderm? by F. A. BATHER. (Jour. London Coll. Sci. Soc. Vol. VIII, pp. 21-23, London, 1901.)

An article which deserves more than passing notice by paleontologists is the admirable summary of our knowledge relating to the echinoderms, which Dr. Bather gave a short time ago in a lecture delivered before the City of London College Science Society. Coming from one who is not only a zoologist but who has had wide experience with fossil forms of life, the subject is viewed from the broadest possible position.

After considering briefly the characters by which an echinoderm may be distinguished from all other organisms, the three principal theories as to the origin and evolution of this group are summed up. These three theories are the ones which have had most influence upon morphologists. They are called the "Calycinal," the "Pentactæa," and the "Pelmatozoic" theories. The last of these seems now to be winning acceptance, but the other two cannot be dismissed without some words.

The first of these theories, the Calycinal of Loven, Carpenter and Sladen, "asserts that certain skeletal elements, with a definite arrangement, form the ground-plan of all echinoderms, which, therefore, are all descended from an ancestor with such composition of its skeleton. The elements in question are the circlets of plates that are present in the theca or calyx of a typical crinoid, namely, the five orals around the mouth, the five radials from which the arms spring, the five basals below the radials, the five infrabasals occasionally found between the basals and the stem, and finally a plate of more dubious nature—the dorsocentral."

The "Pentactæa theory" of Semon crystallized the views of those who held that "the holothurians were the most primitive among echinoderms, and the family Synaptidæ the most primitive among holothurians. Early in the life history of Synapta occurs a stage with five tentacles around the mouth, and into these pass canals from the water-ring, the radials canals to the body-wall making a subsequent, and only temporary appearance. Semon called this stage the Pentactula, and supposed that in its early history the class had passed through a similar stage, which he called the Pentactæa and regarded as the ancestor of all echinoderms."

The third theory seems to have broader foundations than either of the others. "Any theory of the origin and evolution of the echinoderms has to explain those features in the structure and life-history of living echinoderms to which attention has been called; it has to find place for the varied structures of extinct forms, more particularly the ancient cystids; and it has to connect the echinoderms with some antecedent group, whose structure shall not be echinodermal, but comparable with that of some more simple animals now known to us. * * * Opinion trends towards the belief that the most important of these steps was a fixed stage through which the group passed at an early period of its race-history, and the theory that this is the explanation of the peculiarities of echinoderm structure may be called the 'Pelmatozoic theory.'" C. R. E.

Iowa Geological Survey, Volume XI. Administrative Reports. SAMUEL CALVIN, State Geologist; A. G. LEONARD, Assistant State Geologist. Des Moines, 1901; pp. 519, with 12 plates, 9 geological maps of counties, and 43 figures in the text.

This volume contains a statement of the progress of the survey during the year 1900, and of its chief directions of special investigations, by Prof. Calvin; a chapter on the mineral production of the state in that year, by Dr. S. W. Beyer; and detailed reports on the geology of Louisa and Pottawattamie counties, by Prof. J. A. Udden; of Marion county, by B. L. Miller; of Cedar county, by Prof. William H. Norton; of Page county, by Prof. Calvin; and of Clay and O'Brien counties, by Prof. Thomas H. MacBride. About half of the state has now been geologically mapped and described, including more than forty counties variously grouped throughout its whole area.

It is announced that Dr. Beyer is preparing a monograph on the clays of Iowa; that Prof. Norton is preparing a further report on artesian wells, supplementing his previous work; and that a monograph on the grasses of Iowa, by Prof. L. H. Pammel, is in press, to be issued as one of the publicatons of this survey. During the present year investigations of the present soils of the state were expected to be taken up by Mr. Milton Whitney, chief of the Soil Division of the United States Department of Agriculture.

The production of coal in Iowa last year amounted to $6,977,466; of clay industries, $2,305,488; and of stone, gypsum, lead and zinc and iron ore, together about $1,000,000. W. U.

Structure and relations of Uintacrinus; by FRANK SPRINGER. (Mem. Mus. Comp. Zool., Vol. XXV, pp. 1-90, 8 pls., Cambridge, 1901.)

Ever since its discovery, the Cretaceous crinoid Uintacrinus has been of great interest to morphologists and paleontologists. So much has been written about this remarkable type of crinoid that it would seem that nothing more worth recording remained to be told. Yet now comes a new and ponderous monograph containing a mine of suggestive information, exhaustively considered and superbly illustrated.

The great feature of general interest is the bearing of the discussion on crinoid classification. At a single stroke all existing classifications are not only thrown into confusion, but the last prop is taken from under certain of those schemes of systematic arrangement which are claimed to rest securely on phylogenetic foundations.

Uintacrinus has long been regarded as one of the rarities in crinoid collections. Its recorded occurrences were few. Mr. Bather, however, after wide travel in Europe, found the form to be really widely and abundantly distributed. In Kansas, great slabs containing hundreds of beautifully preserved specimens were recently obtained.

To the morphologist, Mr. Springer's studies are a revelation in many ways. Some features which he brings out are unique. The remarkable information relating to the structure of the base is particularly noteworthy. The main distinguishing feature of the two great subclasses of Dicyclica and Monocyclica are here found in one and the same species.

In order to appreciate fully the importance of the present discovery, reference must be made to the recent text-books on zoology and paleontology. "There is no doubt that the occurrence of these two forms of base in this genus is a most extraordinary fact. Nothing like it has ever been observed before among the crinoids, to my knowledge," says Mr. Springer. "Wachsmuth and Springer held the presence or absence of infrabasals to be a good family character, except in case of the Reteocrinidæ, in which dicyclic and monocyclic genera—otherwise markedly similar—were included by us. It was the difficulty presented by these genera that prevented us from attributing to this character a higher value and wider significance. Mr. Bather, on the other hand, considered the difference in the two forms of base as sufficient to separate the Crinoidea Inadunata into two suborders. He has lately in the chapters on the Echinodermata in Part III of Ray Lankester's treatise on zoology, elaborated a scheme of classification, embracing the whole of the Pelmatozoa, on phylogenetic principles, in which he subdivides the class Crinoidea into two sub-classes: Monocyclia and Dicyclica.

"The validity of such a division of the Inadunata was first combated and denied in the monograph of the Crinoidea Camerata, upon grounds which it is not necessary to restate here. There was undoubtedly much plausibility in the suggestion of these two divisions, more as to the Inadunata than to the Camerata. What made it especially attractive was the fact that it was based upon differences in the primitive elements of the crinoid organization, representing phylogenetically different early stages of the only crinoid whose embryology we know. And the argument which was considered by its author to be conclusive, was the assumed fact that there was no such thing as a transition from one form of base to the other. What, then, is the significance of the present discovery in relation to this question? It presents a difficulty far more formidable than the case of the Reteorcrinidæ.

"For those are Lower Silurian types,—among the earliest known crinoids; and it is quite possible to suppose, if the crinoids diverged into two lines of development on this character, that they represent stages somewhat near the point of such divergence. If the two forms of base represented in Uintacrinus had been found in specimens otherwise separable they would, under Mr. Bather's arrangement, have been unquestionably referred to different genera, families, orders, and subclasses. Considering the apparent identity of these forms in every other point of structure, coupled with their mode of occurrence and association, I do not see how any such separation can possibly be made in this case. We therefore have apparently to deal with a case of individual variation, as to this supposed primitive character, within the limits of a species. That is to say, in this species, living in the same locality, having the same environment, floating in the same mass, certain individuals matured to represent one stage of larval development, *i. e.* with infrabasals; and others in another stage, *i. e.* with basals only.

"In short, there are the two supposed distinct types, Monocyclica and Dicyclica, occurring in both young and adult of one and the same species. It will not do to say that the species is dicyclic, but in a certain individuals the infrabasals are not developed, or hidden by the centrale, or have disappeared by atrophy. If this were so the centrale ought to be interradial in both cases; whereas, as already shown, its orientation is reversed from one to the other, precisely as in typical monocyclic and dicyclic forms.

"At all events, we have in Uintacrinus perfect proof that in some cases the characters of a monocyclic or dicyclic base are subordinate to others, and do not mark the line of descent."

The nine beautiful plates of figures give the best graphic representation of Uintacrinus that has ever appeared. C. R. K.

Coal Fields around Tse Chou, China; by NOAH FIELDS DRAKE. (Trans. American Inst. Min. Eng., Vol. XXX, pp. 261-277, 1901.)

On account of the recent exciting changes on the checker-board of the far east, the coal supplies of China have an unusual interest. Every addition to our knowledge of these coal fields since the explorations of Baron von Richthofen, over three decades ago, is now scanned with avidity. Dr. Drake's contribution comes at an opportune time.

The coal fields of Shansi lie about four hundred miles southwest of Peking, near the great Yellow river. The long journey was taken mainly on slow river-boats, and the somewhat limited time at the command of the author, allowed only work to be done in the district around Tsè Chou. Until very recently the hostile attitude of the Chinese government and people towards foreigners and their enterprises, has kept the coal-fields from being developed.

The rock formations are roughly divided into three great terranes. There is a basal limestone formation, the *Kohlenkalk* of Richthofen, aggregating 2,000 feet or more in thickness; a median formation composed of shales, coals, sandstones, and a flint-bearing limestone bed, aggregating about 300 feet in thickness; and an upper terrane made up of shales, and sandstones of about 1,000 feet in thickness.

The workable coal lies in one bed 250 feet above the flint-bearing limestone. "In the Tsé Chou region the average thickness of the main or workable coal-bed is probably not less than twenty-two to twenty-three feet. At the mine about one and a half miles west of Hsi Ta-yang, the coal is worked through a shaft 329 feet deep. I had no opportunity to measure the full thickness of the bed, or to examine more than the part that is being mined. Only the lower ten to twelve feet of the coal is being mined. I was told by the Chinese miners that the full thickness of the bed is thirty feet (Chinese), which is equivalent to about thirty-six feet (English)." There is no waste material in the coal bed in any of the mines. If twenty-two feet is taken as the average thickness and 1.5 as the average specific gravity of the coal, there are about 3,000,000,000 metric tons of coal within the 150 square miles, which is about the amount of the coal area included in the map. It must be remembered that this area is only a little of the ragged edge of the great coal fields of Shansi. Most of Shansi has been found underlaid by large coal fields, and the coal area of this province is greater than that of Pennsylvania.

All the coal of the Tsé Chou region is anthracite. The present style of working the mines and transporting the coal presents a striking contrast to what might be done were modern methods used. The great thickness and the almost horizontal position of this coal bed make it practicable to run long lines of railroad tunnels through the bed and load the cars in the mines for distant transportation. C. R. K.

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PERSONAL AND SCIENTIFIC NEWS.

DR. E. R. BUCKLEY of the Wisconsin Geological Survey, has been elected State Geologist of Missouri.

PROF. R. D. SALISBURY of the University of Chicago, has been in Montana, in charge of several geological parties from that university.

DR. LOOMIS of Amherst, has been spending the summer with the American Museum parties in South Dakota, Wyoming and Colorado, as volunteer assistant.

MAJOR A. W. VOGDES has been transferred from Fort Hamilton, to the Artillery District of San Diego. His address is San Diego Barracks, California.

DR. THOMAS L. WATSON, of the Geological Survey of Georgia, has been appointed to the chair of geology and botany in Denison University, at Granville, Ohio.

DR. W. D. MATTHEW of the American Museum of Natural History, has been spending the summer in Wyoming and Colorado, collecting vertebrate fossils for the museum.

DR. F. H. KNOWLTON recently made large collections of fossil plants in the John Day basin, Oregon. He was accompanied by Prof. J. C. Merriam of the University of California.

MR. J. E. SPURR, who is in the employ of the Sultan of Turkey, has begun examination of Macedonia and Albania. His residence is on the banks of the Bosphorus, his address being Constantinople, *via* Open English mail.

The officers of Section E, elected at the Denver meeting of the Association for the Advancement of Science, are O. A. Derby, Sao Paulo, Brazil, vice-president; and F. P. Gulliver, Southboro, Mass., secretary. Prof. Asaph Hall, Cambridge, Mass., was elected president of the Association.

The earliest traces of man. Sir Henry Howorth, author of "The Glacial Nightmare," considers paleolithic man was preglacial, and neolithic man postglacial. In a work, soon to be issued by him, he condenses a vast mass of evidence justifying that classification. He has an interesting article on this topic in the *Geological Magazine* for August.

Geology of the South African Republic. The late official geologist, M. Molengraaf, has prepared and issued what may be considered his final summary report. It is printed in the bulletin of the Geological Society of France, fourth series, vol. I., No. 1. June, 1901. This survey, interrupted and terminated by the unfortunate war of the last two years, is thus not entirely lost. The report extends through seventy-nine pages, and has a general geological map.

American meteorites described. In the Vienna *Annalen K. K. Natur-historischen Hofmuseums*, band 15, Heft 3-4, 1900, professor Cohen publishes his "Meteoreisen-Sudien XI." This includes new descriptions of the following American meteorites: Illinois Gulch, Deer Lodge Co., Montana; Deep Springs farm, Rockingham county, North Carolina; Hammond, St. Croix county, Wisconsin; Cacaria, Durango, Mexico; Mezquital, Durango, Mexico; Murphy, Cherokee county, North Carolina; St. Francis county, Missouri; Crosby Creek, Cooke county, Tennessee; Cañon Diablo, Crater mountain, Arizona; Merceditas, Chanaral, Chili; Kendall county, San Antonia, Texas; Minas Geraes, Brazil; Mount Joy, Adams county, Penn., (schreibersite).

The summer scientific meetings at Denver, Col., Aug. 27-31, were notable, not only for their geographic location, i. e. in the eastern foothills of the Rocky mountains, but for their success as scientific meetings. The geologists who attended were greatly satisfied with the carefully arranged programs of geological excursions, and with the character of the papers that were presented. Prof. C. R. Van Hise, vice-president of Sec. E of the American Association for the Advancement of Science, gave an evening popular address on the methods of deposit of ores by underground waters. He questioned the possibility of the origin of ore-deposits by upward flowing waters, and urged instead that such deposits originate, in the first instance, from downward moving waters, thus differing from Posepny. He thus reached the conclusion, borne out by facts cited, that after passing below the surface oxidized zone of mineral veins, the richest deposits are in the upper portion,

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as it progresses, and provides, as a penalty, a fine "not exceeding one thousand dollars or two years in jail" for divulging information concerning the public school, university, asylum or State lands in advance of publication. Section 4 provides "for assays, analyses and other scientific examinations of specimens of mineral substances found in the state, and for the collection and distribution of statistics relating to the mineral production of the state." For assays, etc. "uniform and reasonable charges shall be fixed." By Section 5 provision is made for instruction in the University "in practical, economic and field geology and mineralogy." Section 6 authorizes the removal of the specimens, books, and equipment of the former Geological Survey of Texas (Dumble survey) to the University. These are loaned to the Board of Regents until such time as the state may otherwise desire to use them. Section 7 is as follows: "For the purpose of carrying out the provisions of this act, the sum of ten thousand dollars per annum for two years, or so much thereof as may be necessary, is hereby appropriated out of the general revenue of the state; provided that said mineral survey of the state shall be completed within two years."

The survey was organized by the Regents of the University on May 4, 1901, at which time the following appointments were made:

William Battle Phillips, Ph. D., Professor of Field and Economic Geology and Mineralogy, Director.

Henry Winston Harper, Ph. D., M. D., Associate Professor of Chemistry, Chemist.

Benj. F. Hill, M. S., M. A., Assistant Geologist.

Omerod H. Palm, B. S., and S. H. Worrell, Assistant Chemists.

The first publication of the survey, issued under the date of July, 1901, but delayed until August, bears the title "Texas Petroleum." It consists of 102 pages, two maps, and numerous illustrations, and is a history of the oil development in the state up to the date of publication.

President Prather, of the University, under the date of July 5, makes the following announcement: "It is expected that material will be collected for a similar bulletin upon the gold, silver, copper, lead and zinc prospects and mines west of [illegible] about the first of next year. Following this [illegible] be issued a bulletin upon the extent and [illegible] of Texas deposits of cement rock, sulphur, [illegible] building stones, etc."

The work thus far done is extremely creditable to the [illegible] Phillips is a man of great energy, who, notwithstanding the [illegible] will undoubtedly accomplish much that will prove of lasting benefit to the state.

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Sincerely
Theodore G. White

THE AMERICAN GEOLOGIST.
VOL. XXVIII. PLATE XXIII.

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THE
AMERICAN GEOLOGIST.

VOL. XXVIII. NOVEMBER, 1901. No. 5.

THEODORE GREELY WHITE.

BY HEINRICH RIES, Ithaca, N. Y.

PORTRAIT.

Theodore Greely White died at his residence in New York city on July 7th, in the twenty-ninth year of his age. His death was sudden and unexpected, and will be much regretted by all geologists who were acquainted with him and his work.

Dr. White was born August 6th, 1872. He received his early education in New York city, and even while still a schoolboy showed the deepest interest in natural science and through his contagious enthusiasm interested many others of his age in the same subject. He entered the Columbia University school of mines in 1890, and during his college vacations devoted much of his time to botanical work, making a detailed study of the flora of Mt. Desert, Me. He received the degree of Ph. B. from Columbia in 1894, his graduation thesis being "The Geology of Willsboro and Essex townships," N. Y. This piece of work was really the beginning of a far larger investigation, which he took up for his doctorate, viz. the study of the Ordovician in the Lake Champlain valley.

Subsequent to his graduation, Dr. White remained at Columbia as a post-graduate student in geology, taking his M. A. degree in 1895 and his Ph.D. in 1898. In 1895 and 1896 he served as lecturer for the Department of Public Instruction, New York. From 1896 to 1900 he was assistant in the Department of Physics, Columbia University, and in this work showed marked success as a teacher.

Dr. White's work on the Ordovician of the Lake Champlain valley, had consumed much of his time for several years, and the manuscript was fortunately in such form that it can be sent to press, for it represents a splendid piece of work and one at which he had labored almost unceasingly. He also had nearly completed a paper on the petrography of the rocks around Mt. Desert, Me.

Always an active church member, he decided in 1900 to give almost his entire time to philanthropic work among boys and young men. He was especially interested in boy's clubs, and with his own ample means was engaged in establishing a boy's club known as the Gordon House at the time of his death. Indeed it was his untiring devotion to this cause which so taxed his strength that when taken ill, he had no vitality left with which to combat the disease.

Dr. White was a man of great energy and perseverance, and never left a piece of work until he felt that everything had been done towards its completion which was possible, and it is most sad that his life should have been cut off when he was entering upon a most promising career.

He was a fellow of the Geological Society of America, the New York Academy of Science, Torrey Botanical Club, American Association for the Advancement of Science, New York Mineralogical Club, and other organizations. For two years prior to his death he served as secretary of the geological section of the New York Academy of Science.

He frequently contributed to various periodicals and a list of his geological papers is given below:

Publications of Dr. Theo. G. White.

The geology of Willsboro and Essex townships, Essex county, N.Y. Trans. N. Y. Acad. Sci., Vol. XIII, pp. 214-233, pl. 6 and 7.

An account of the Summer's Work in Geology on Lake Champlain (with G. van Ingen.) Trans. N. Y. Acad. Sci., Vol. XV, pp. 19-23.

The Upper Ordovician Faunas in the Lake Champlain Valley. Bull. Geol. Soc. Amer., Vol. X., pp. 452-462.

The Original Trenton Rocks. Amer. Jour. Sci. (3), Vol. II., 1896, pp. 430-432.

The Faunas of the Upper Ordovician Strata at Trenton Falls, Oneida Co., N. Y. Trans. N. Y. Acad. Sci., Vol. XV., pp. 71-96, pl II.-V.

Report on the Relations of the Ordovician and Eo-Silurian Rocks in portions of Herkimer, Oneida and Lewis Counties. Appendix A. Ann. Rep. N. Y. State Museum, 1899, p. 28.

A Contribution to the Petrography of the Boston Basin. Proc. Bost. Soc. Nat. Hist., Vol. XXVIII., No 6, pp. 117-156.

NEW ZEALAND IN THE ICE AGE.[*]

By C. H. Hitchcock. LL. D.

PLATES XXIV-XXVI.

It was my good fortune two or three years since to spend a month in New Zealand, travelling the entire length of the two principal islands. During this period I noted the peculiar characteristics of the glacial phenomena; and will briefly describe them as they appeared to one familiar with the ice-markings of North America. The New Zealand geologists have been diligent in their study of these vestiges, with considerable divergence in their opinions. I append a list[†] of the papers written by them which I have consulted, including explorations in the Southern Alps among the living glaciers, The conclusions to be stated later are my own.

New Zealand consists mainly of two large islands, the one southwest of the other in direct line, both together being about one thousand miles long. It is only the southern island that possesses active glaciers and important evidence of ancient ice-action. It has an area of 55,000 square miles, the two together amounting to 100,000. The trend is northeast and southwest; width on the average 140 miles; length about 500, lies between latitudes 41° 30′ and 46° 40′, longitudes 166° 30′ and 174° 30′ west of Greenwich. A range of high mountains is situated nearer the west than the east coast, reaching the maximum of 12,349 feet in Mt. Cook. Only two other peaks exceed 11,000 feet, and there are thirteen more than 10,000 feet high in the Southern Alps. The predominant winds are from the northwest and there is a greater precipitation of moisture on the northwest coast, the extreme annual amounts of rain fall being 126 inches at Hokitika on the northwest and twenty-five inches at Christ Church on the southern side.

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[*] Read before the American Association for the Advancement of Science at the New York meeting.

[†] New Zealand, its Physical Geography, Geology and Natural History, etc. by F. Von Hochstetter, 1867, English edition.
Geology of Canterbury and Westland. By Julius Haast, 1879.
With Axe and Rope in the New Zealand Alps. By G. E. Mannering, 1891.
Camp Life in Fiordland. By William McHutcheson, 1892.
Official Reports of the Department of Lands, 1893-1897. By S. Percy Smith, General Surveyor.
Pioneer work in the Alps of New Zealand. By A. P. Harper, 1896.
Climbs in the New Zealand Alps. By E. A. Fitzgerald, 1896.
Report of the Research Committee appointed to collect evidence as to glacial action in Australasia in Tertiary or Post Tertiary time. Captain F. W. Hutton, reporter for New Zealand. From Proc. Australasian Association for the Advancement of Science.

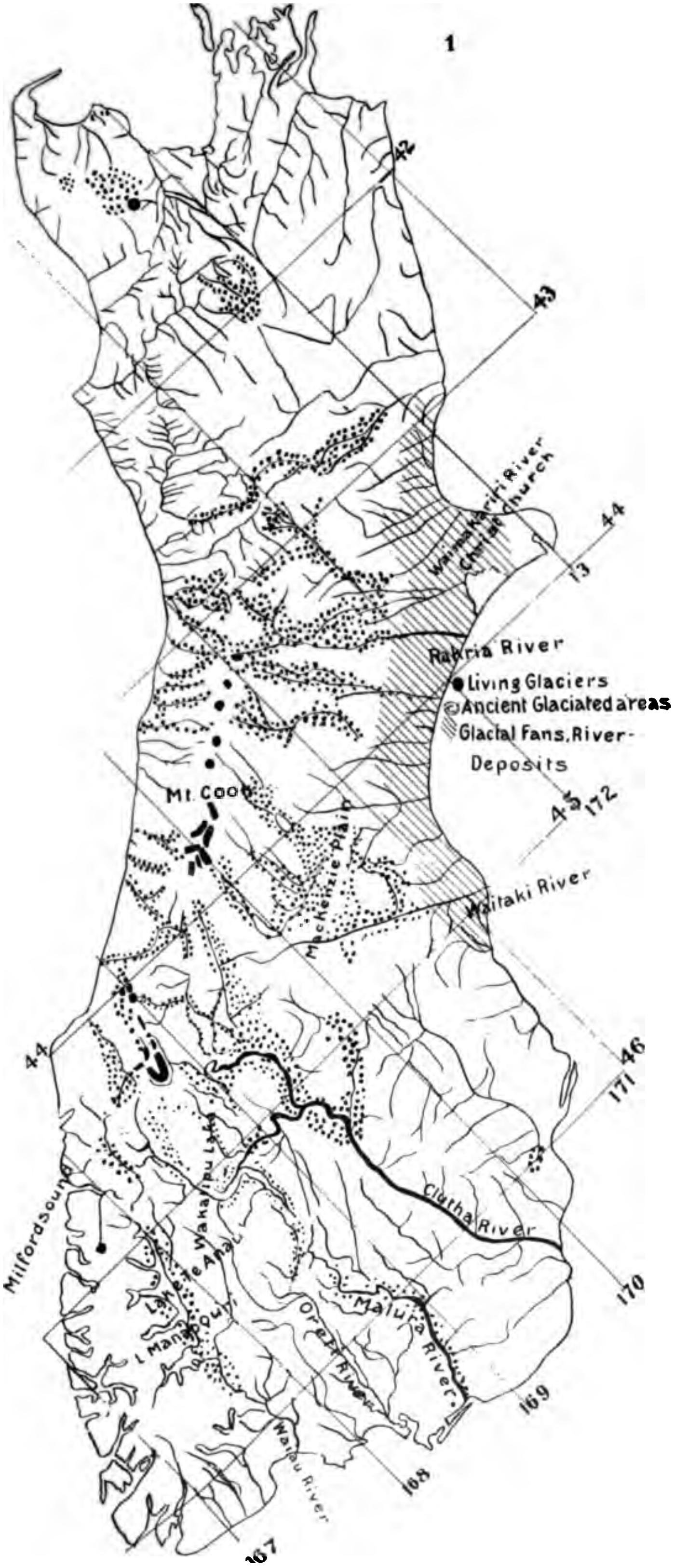
The terminal faces of the glaciers now in motion vary with their position. The most northern are near latitude 41° at Mt. Arthur descend to 3,600 and 3,000 feet on the eastern slopes, and to 3,000 and 2,700 feet on the western slopes. In the Alps the Tannan glacier terminates at the altitude of 2,500 feet: the Francis Joseph and Fox glaciers on the west of the slope terminate at 950 and 734 respectively. Farther south, as upon Mt. Earnslaw, the glaciers terminate much higher up and diminish in rise. There may be glaciers above latitude 45° unknown to mankind because of the lack of exploration.

THE FIORD REGION.

In the earlier periods glaciers must have abounded in this elevated southwest portion of the island, because of the existence there now of numerous fiords. In the New Zealand summer (January) steamers visit these fiords or sounds for the benefit of tourists. There are thirteen of these interesting chasms on the southwest coast stretched over two degrees of latitude, the most romantic being Mitford sound. The general altitude of the high plateau is from 4,000 to 5,000 feet, while several peaks rise to 7,000 and 9,000 feet. The excursion steamer sails from one fiord to another in the night time, and the following day is spent in explorations of the interior valley. The soundings of the mouths of the fiords indicate depths of forty fathoms and less; but farther in they exceed 100 fathoms. On the opposite side of the ridge the corresponding fiords may be recognized in lake Te Anan, Manapouri, Wakatipu, Wanaka and Hawea, all of which are true glacial lakes formed by the damming of the fiord by terminal moraines. There may have been here a different change of level, because the present outlet of the lakes are much higher than the inlets to the sounds.

Plate xxiv represents the present locations of the active glaciers; the areas occupied by the ice at the time of maximum glaciation; the positions of the fiords and glacial lakes, and several glacier fans or river deposits, perhaps partly marine. The map is defective in that I have been unable to present all the glaciers and the extreme limits of the fans and plains. There must be a multitude of glaciers northeasterly from the region of Mt. Cook, or the southern alps, and possibly a few in the snow fields bordering the sounds.

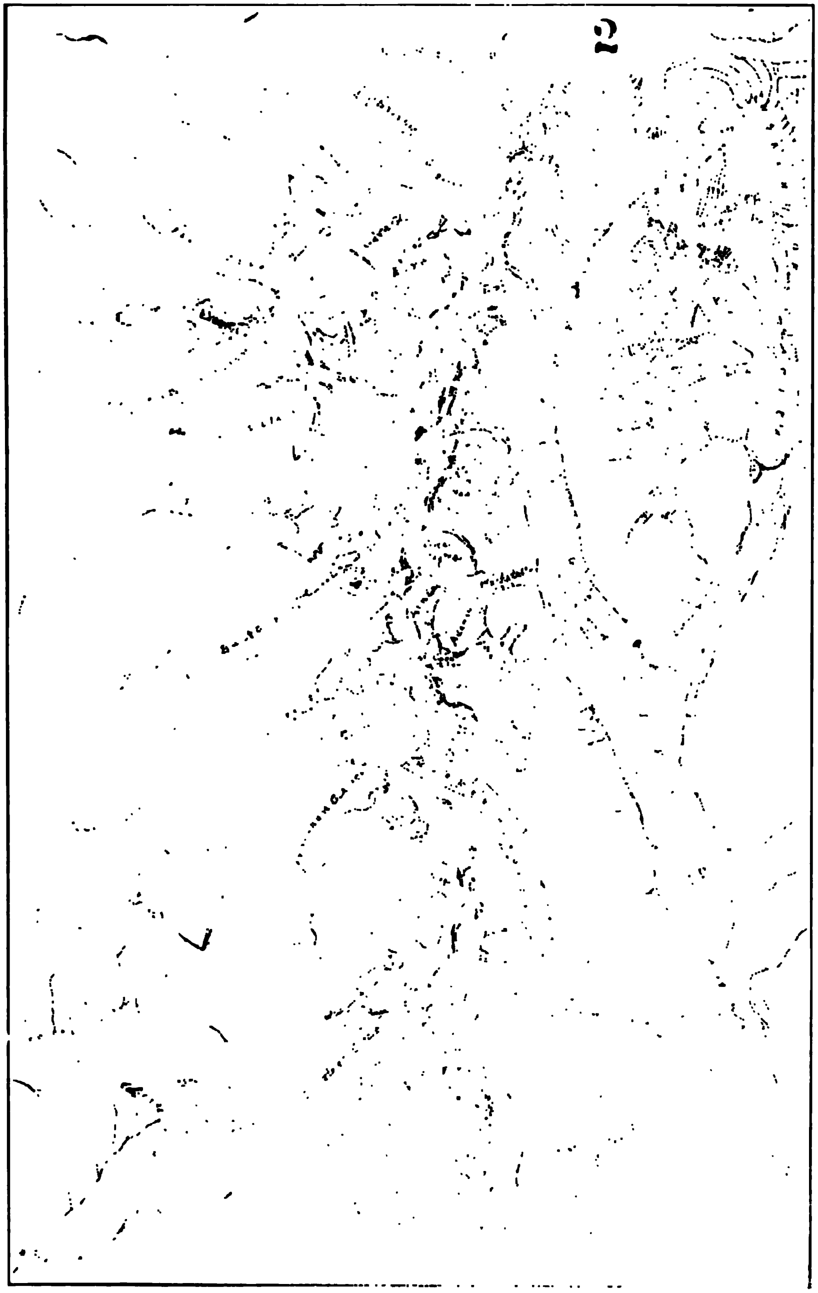
1


42
43
Waimakariri River
Christchurch
44
13
Rakaia River
● Living Glaciers
◎ Ancient Glaciated areas
▨ Glacial Fans, River-Deposits
Mt. Cook
45
172
Mackenzie Plain
Waitaki River
46
171
44
Clutha River
Wakatipu Lake
Milfordsound
Lake Te Anau
L. Manapouri
Oreti River
Mataura River
170
169
168
Waiau River
167

[illegible] river below Frankton the delta is about [illegible]. The Shotover and Arrow rivers have been famous [illegible] the large amount of placer gold contained in these [illegible] of Wakatipu, there are other [illegible] terraces at least a hundred feet high upon the [illegible] upon the south and five upon the north side [illegible] along the lake the levels of the terraces [illegible] higher where the tributary streams discharge [illegible] northern [illegible] away from Wakatipu. The high [illegible] of sands and gravels constituting the [illegible] over two feet higher than [illegible] from the glaciers of Mt. Earnslaw [illegible] glaciers covering the divide between the [illegible] northern flowing streams beyond. The [illegible] wide and is full of meandering streams. [illegible] the right in the figure are those of Mt. Earnslaw [illegible] the left in the distance [illegible] peaks [illegible] glaciers are not visible. In some of the high [illegible] lake Wakatipu are caves containing numer[illegible]. The Clutha river combines the [illegible] lake Wakatipu with that from Wanaka and Hawea [illegible] still farther to the northeast and fed by [illegible] winding and the valleys narrow reaching [illegible] the Balclutha, near its mouth [illegible] accumulations of loess.

THE SOUTHERN ALPS

[illegible] by the southern alps, where [illegible] and the most extensive glaciers [illegible]. The government has had surveys [illegible] the higher peaks have been climbed by [illegible]. It is the policy of the government [illegible] this and other interesting [illegible] the hotels and places of [illegible]. In the Alps the [illegible] of the [illegible] glaciers. Plate XXV is a copy of [illegible] of the southern alps after [illegible] of the government survey[illegible]



MAP OF THE SOU [illegible]

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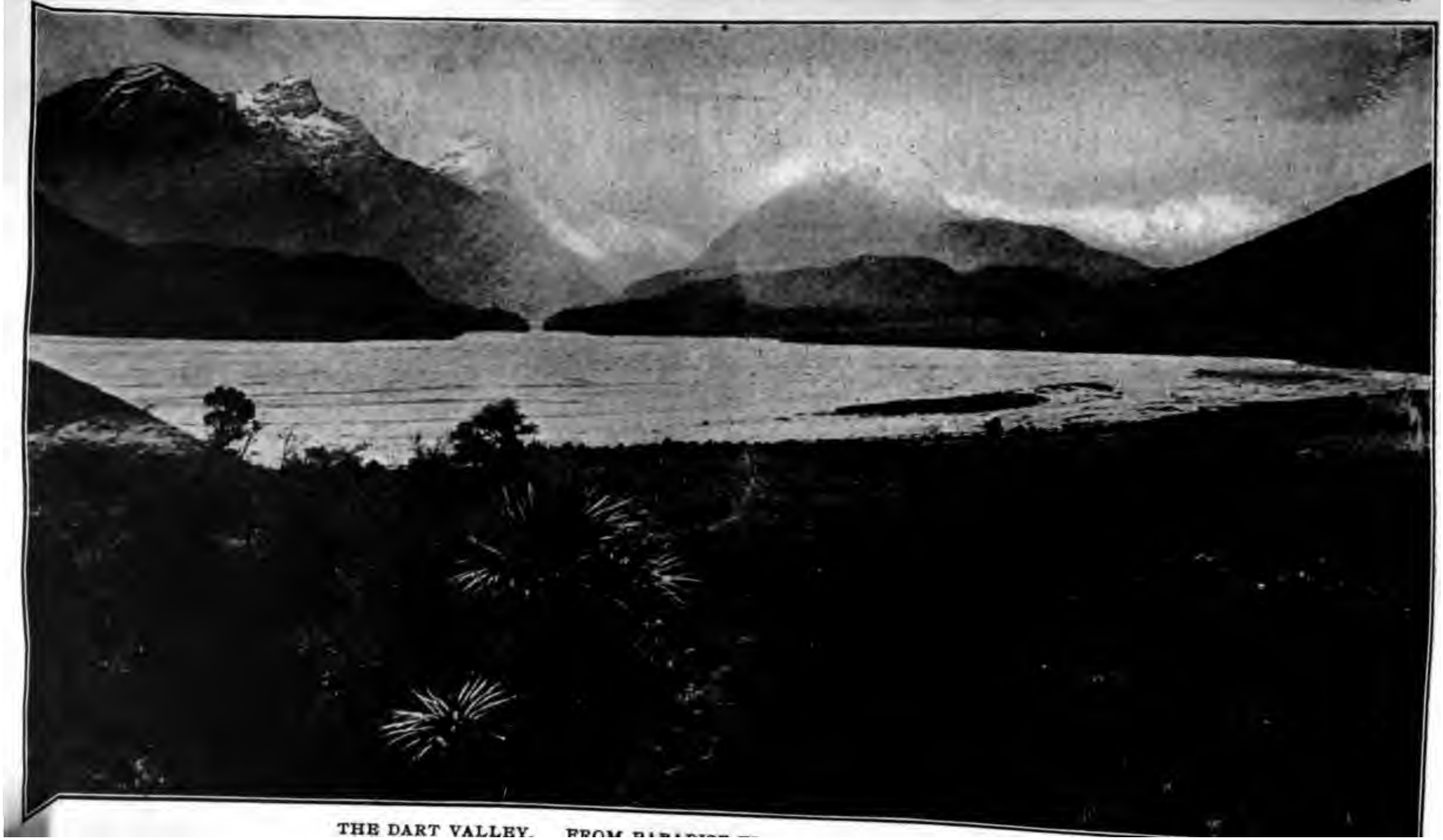

THE DART VALLEY. FROM

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adding his own observations. The area is about thirty miles by eighteen, and the glaciers are situated upon both sides of the main divide. The books of Fitzgerald, Harper, Mannering and Green contain the records of explorations and ascents as thrilling and daring as any in alpine annals. Mt. Cook, the highest of the peaks, was first practically ascended by Rev. W. S. Green, in 1882, and later by Zurbriggen the celebrated Swiss guide, in 1895, who had gone to New Zealand in the employ of E. A. Fitzgerald.

The Tasman is the most important of all these glaciers. It is eighteen miles in length, rising between Mts. Elie de Beaumont and Darwin, 10,200 and 9,715 feet high, and receiving as tributaries on the left the Rudolph, Forrest-Ross, Kaufman, Haast, Freshfield, Hochstetter and Ball glaciers; on the right Darwin, Bonney, Beetham, Barkley, Langdale, Walpole, Reag, Dorothy and the Murchison, second only in size to the Tasman. The water from the Mueller and Hooker glaciers joins the drainage from the Tasman below the Hermitage, which gives a more extensive flood plain than that described for the Dart river. The Tasman has the altitude of 6,136 feet two and a half miles below its remotest beginning; falls to 4,178 feet opposite the Hochstetter glacier, where it is entirely covered by moraine material. This debris covers six and one-half miles extent of the lower part of the Tasman, being one and one-fourth miles wide at its lower end and two miles wide at the union with the Murchison. It is less than three-fourths of a mile wide for three miles of its course and broadest high up between Mts. Beaumont and Darwin. The altitude of the surface of the ice at the terminus is 2,490 feet, the wall being 140 feet. The moraine is continuous for eleven miles from the terminus up to the head of the Rudolph glacier. Hochstetter glacier starts in a great oval mass, two by three miles in extent, between Mts. Cook and Haast, making a great plateau on the north, and joined by the two tributaries Linda and Adamson on the south, and the united mass falls over a precipice nearly 2,000 feet high before uniting with the Tasman. The pieces unite by regelation and move four miles down the slope. On the west edge of the Tasman, upon the moraine descending from the Ball glacier, a hut has been erected for the accommodation of travellers, 3,402 feet high, and twelve miles distant from the Hermitage, 2,506 feet, and it can be reached easily by horses. It is a very convenient starting point for the exploration of the Mt. Cook region. The total area of the Tasman glacier is twice that of the Aletsch glacier in the Swiss alps.

The Murchison rises farther to the northeast than the Tasman, from Mt. Cooper 7,837 and Aylmor 8,819 feet, and curves so as to move southerly at the altitude of 5,791 feet. Mannering joins it at 5,084 feet, followed on the same west side by the Dixon, Wheeler, Baker, Cascade, Onslaw and Barnett, glaciers. The Harper and Aider glaciers are tributary on the east side near the upper limit. The Murchison makes a sweep of 180° before being joined by the Mannering, which has brought some debris to cover its own mass, while the Murchison is free for a mile and a half below the junction. The extreme length of the moraine covering is four miles, and the lines of blocks are distinct as they are upon the Tasman. Each tributary pushes debris upon the main glacier whose angles of direction soon change their course to fit the motion of the larger mass. The extreme length of the Murchison glacier is eleven miles, with the usual width of a mile. Below the terminal cliff vigorous streams of water meander across the valley for five miles till it reaches the Tasman, and then the water is crowded to the east side of the ice. The terminal cliff is eighty feet high or 3,385 A. T. The flood plain below commences at 3,308 and strikes the Tasman at 2,869 feet, a fall of eighty-eight feet per mile

The Mueller glacier reaches nearly to the Hermitage and has piled up a huge moraine 250 feet high behind the hospice. A general view of the lower portion shows morainic bands very similar to those upon Agamir's classic diagram of the Viesch glacier. The Hooker glacier comes down from the west flank of Mt. Cook and exhibits finely the moraines and the ribbon structure of glaciers. It is formed by the union of the tributaries Empress, Noeline and Mona glaciers.

The other glaciers shown upon the map are tributary to the rivers draining the northwest slope of these alps; being at the south, the Twain and Copley, branches of Karangua river; then the Cook, the Balfour and Fox branches of Cook river; the Wakupapa and Waiho rivers. The Douglass glacier is in two parts; the highest commencing as névé upon the west flank of Mt. Septon, and running parallel with the main glacier for four miles, and supplying it with avalanches along its whole course, nowhere touching the lower body. The precipices over which the ice falls vary in hight from 200 to 1,500 feet, over which avalanches fall from twenty to twenty-five feet every hour. Arrows upon the map indicate the general direction of this movement.

The Fox glacier has been explored considerably because it is the nearest of the west coast glaciers to settlements, and descends the nearest to the sea level (734 feet). Cook river of which the Fox is a tributary, is a "wide unsightly stretch of shingle flats covered with large masses of drift timber, through which the water meanders in numberless channels." At the mouth of the Fox branch these flats are two miles wide. Some of the moraine piles reach the hight of 1,500 feet. The principal tributary of the Fox is the Victoria glacier, whose terminus is over a precipice one thousand feet high. The Fox arises from the western slope of Mts. Haidinger and Tasman and is ten miles long with a remarkable local névé at its source. The terminal face is 756 feet high, and is covered by debris for fifty chains. It is said that the retreat from melting is apparent in the middle rather than at its end. Measurements in the winter showed a motion in this glacier from twenty-one to thirty-one feet in twenty-eight days. Near the lower end there is a fine hot spring and a boulder thirty feet high and three hundred and fifty in circumference. Tony's rock, lower down, is 156 feet high and has a diameter of 268 feet. In the Copeland valley Fitzgerald measured a boulder 300 by 200 by 100 feet in linear dimensions and "there were others still larger." There is a large tree growing upon the top of one. I have not seen any notice of any larger boulders than these are in any glaciated district, and their immense number interferes seriously with exploration.

Observations upon the rate of motion of several of these glaciers have been made with care. On the Tasman, in the summer, the average daily rate was from ten to eighteen inches; in the Murchison, the average daily rate was from one-half to seven or eight inches; on the Hooker, from 1.1 to 5.4 inches; on the Mueller from 4.1 to 9.6 inches. The Franz Joseph glalarger virgin area open for Alpine tourists. Many of these peaks and ice plains await the tread of explorers. Mt. Septon is the Matterhorn of the Southern alps, rising from the valley to fully as great a hight as does its prototype from the village of Zermatt and at a steeper angle. At the Hermitage there is a constant series of avalanches, startling one by their deafening roar, and being plainly visible.

3. There are peculiarities in the various phenomena. Lateral and terminal moraines constitute the bulk of the deposits, containing very few scratched stones. There is no ground-moraine, or boulder clay containing glaciated pebbles. Silts are not uncommon. Eskers and drumlins have not been observed. Loess is recognized at several localities, always of aqueous origin. Embossed rocks and smoothed surfaces are less conspicuous than in New England, and it is claimed that their obscurity is due to their great age. Glacial striæ are scarce and none are found upon the tops of ridges. The scarcity may be due in part to the absence of protecting till.

4. To an American the glacial fans are the most conspicuous and characteristic features of the New Zealand ice work. All the rivers proceeding from the existing glaciers are very turbid, and of large volume in the summer season. In this respect they strongly contrast with the streams coming from highlands without ice, which shrink to small dimensions or dry up. The first may be styled *snow rivers*, and the second *rain rivers*.

5. The opinion prevails at the antipodes that the greatest extension of the glaciers occurred in the Pliocene period. Capt. F. W. Hutton in a table of the sedimentary formations in New Zealand, assigns the older glacial deposits to the older Pliocene* at the base of the Wanganui system, whch is the equivalent of the Pliocene. He concludes that the "former great extension of our glaciers was caused by greater elevation of the land during the interval between Paseora [Miocene] and the marine beds of the Wanganui system."*

Sir James Hector, director of the Geological Survey, says that the Pliocene was characterized by the "greatest activity of the volcanic forces"; and in the south island "the great area of land above the shore line intensified the erosive action of

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**Quar. Jour. Geol. Soc.*, vol xli, pp. 194-211.

the glaciers radiating from the mountain centers, and gave rise to enormous deposits of gravel, such as compose the greater part of the Canterbury plains" etc.* Dr. Haast refers the glacial deposits to both the upper Pliocene and Pleistocene.† A very natural conclusion may be that the glacial age in New Zealand, representing that of the antipodes generally, preceded the same period in the northern hemisphere. This will help us in formulating glacial theories, since both polar regions were glaciated alternately.

6. The large cursorial birds, or the *Moas,* of which eighteen species have been described, seem to have flourished in the ice age and the early Pleistocene. From a study of the distribution of the genera and species it is concluded "that the two islands of New Zealand were separated from each other after the development of most of the genera, but before the development of the known species, except of course Anomalornis antiquus of the Miocene, and that they have not since been united." The older deposits are in the gravels and caves, the latter in turbaries. For convenience I add a list of the species, after Captain Hutton. A. oweni, Haast; Dinornis giganteus, Owen; Megalapteryx tenuipes, Lyd.; Cela carta, Owen; D. ingens, Owen; Anomalornis gracilis, Owen; Euryapterx exilis, Hutton; D. struthioides, Owen in part; A. didiformis, Owen; Pachyornis, rothschildi, Lyd.; P. pygmaeus, Owen; Dinornis dromæoides, Owen; Palapteryx geranoides, Owen.

From Trans. New Zealand Institute, 1896. Nearly all these species are reproduced in the Canterbury Museum at Christ Church. This collection has been built up chiefly by means of exchanges of the Dinornis bones with other objects, with European and American institutes. Dr. Julius Haast founded the museum and Capt. F. W. Hutton is its present director.

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*Catalogue of geological exhibits at the Indian and Colonial Exhibition, London, 1886.

†Geology of Canterbury and Westland, p. 251. 1879.

REEF STRUCTURES IN CLINTON AND NIAGARA STRATA OF WESTERN NEW YORK.

BY CLIFTON J. SARLE, Rochester, N. Y.

PLATES XXVII-XXXI.

At no other point in the United States, excepting possibly Niagara, the type locality, is there so fine an opportunity to study the Niagara series, as in the lower gorge of the Genesee at Rochester, [illegible] and the display of Clinton strata is un[illegible]

A phenomenon which early drew the writer's attention in the study of this exposure, is the occurrence in the Clinton limestone of certain irregularly bedded masses which, owing to differential weathering, project beyond the general ledge face, being apparently parts of irregular lenses.

In the various exposures of this horizon, for about a mile along the Genesee, upwards of forty examples have been observed, this number being increased by others found in sewer [illegible] in the northern quarter of the city. The "west side" sewer, made in the winter of 1895-6, afforded seventeen masses in a distance of seven or eight hundred feet. The workmen engaged in this excavation called them boulders because of their shape and superior hardness. The latter [illegible] accounts for their prominence on weath-[illegible]

[illegible] Rochester I have found them along the Clinton [illegible] Niagara river on the west and Marble Sec-[illegible] point on the east, a distance of about [illegible] miles. Over one hundred examples [illegible] carefully studied by the author. They [illegible] areas or may occur isolated, or in [illegible] as to more or less completely coa-[illegible] under Lewiston heights, eleven [illegible] between this locality and [illegible] in length has afforded but [illegible] nearly a score are [illegible] affords one or [illegible] creek they form an irreg-[illegible] for several rods along the [illegible] from Salmon creek three

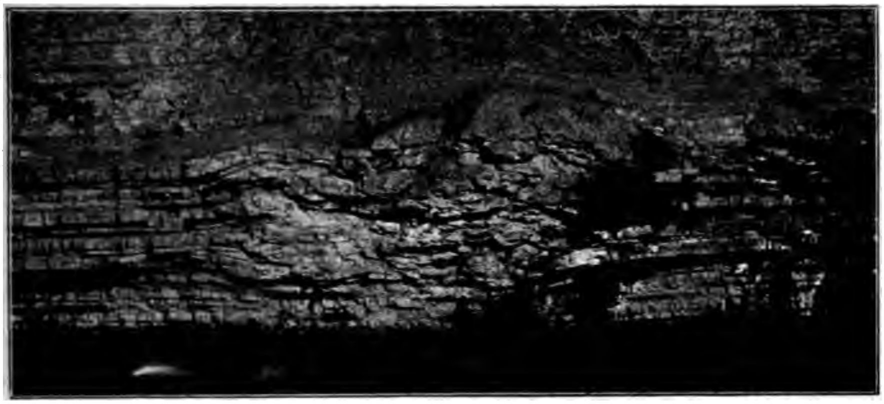

FIG. 1. Mass formed of two unequal growths of Fistulipora extending through the upper six feet of Clinton upper limestone into the base of the Rochester shale. Dimensions 32 x 11 feet.

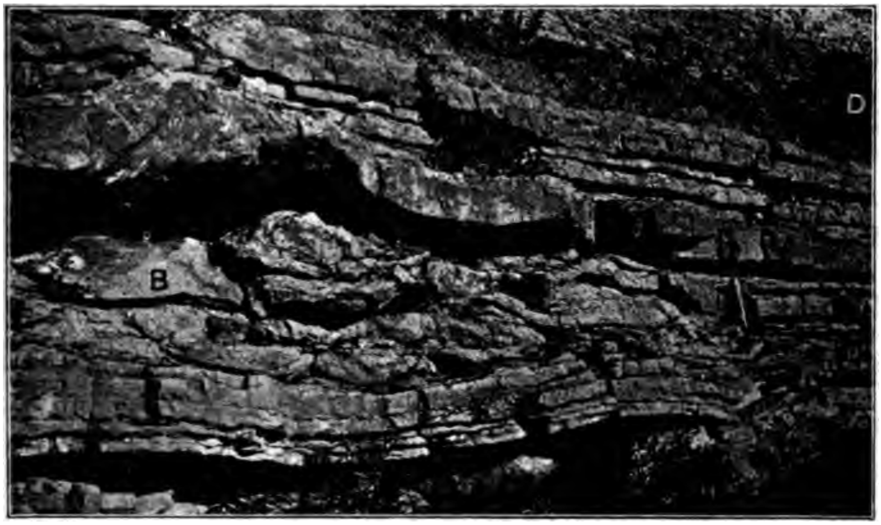

FIG. 2. Remnant of eroded mass, showing shale encroachment, pocketings, etc. Spaces between limestone layers formed by removal of shale. A—10 inch stratum, flexed in conformation to removed part of the mass; B—thickened stratum at side of Fistuliporid head; C—oldest remaining portion of the mass; D—Rochester shale. Breadth 18 feet.

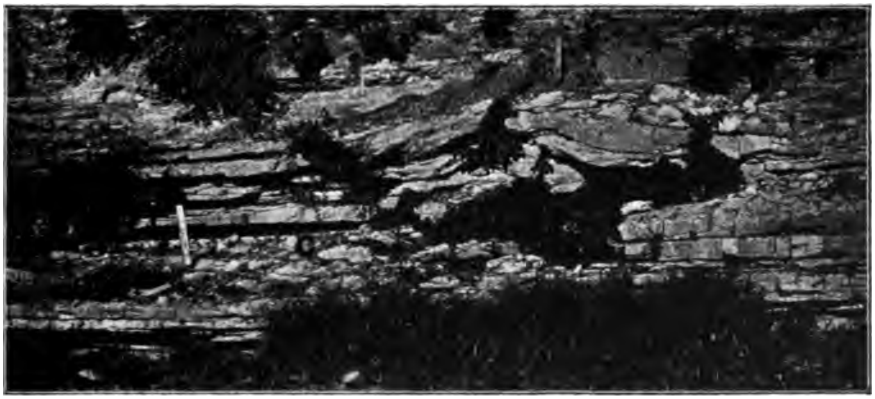

FIG. 3. An oblique growth which probably started in the depression at B. The *growth, C, is made of* imbricating dome-shaped shells of Fistulipora. The oblique *fully 12 feet long.* A—*Rochester* shale. B—portion chiefly Tribolites and Cephalo

REEFS IN THE GENESEE RAVINE AT ROCHESTER.

Above the R. W. & O. R. R. bridge.

[illegible] TRANSLATIONS

miles to the westward. The Clinton masses are limited to the upper half of the Clinton upper limestone or projecting into the Niagara shale above, but occur at varying horizons within this limit; neighboring masses usually start at about the same base level and by far the greater number but a little above the mid-plane of the limestone stratum.

In general these accumulations may be roughly compared to greatly thickened lenses. [Pl. xxx, Fig. 7.]* However, they may be elongated or oblique to the vertical axis. [Pl. xxvii, Fig 3.] In size they vary considerably. The extremes observed range from one to fifteen feet in thickness, and in breadth from two to fifty feet, though they may, as cited at Marble creek, form an irregular, continuous stratum.

The strata above and below the lenses are often so strongly bent in conformity to these less-yielding masses as to produce an arching or doming of the overlying Rochester shale and a sagging or basin-like depression which extends into the Clinton upper shale beneath. This deformation, taken with the rough and irregular structure, gives them the semblance of inclusions. More careful inspection, however, shows the limestone strata on either side continue as a rule into the mass [Pl. xxvii, Fig. 1], where they may double in thickness and the bedding becomes lost in the obscure structure. Shale partings thin out as they reach the lens or encroach but a little distance upon it, [Pl. xxvii, Fig 1.] with only rare exception appearing to extend through, dividing the mass into upper and lower portions. Beds running into the upper portion are traced with upper flexure, those into the lower portion with a downward.

From these facts it would appear that the lenses were produced by local thickening of the successive limestone layers in the process of their deposition. Hence it is to be inferred that their construction was not rapid, but in some instances continued through the time when the latter half of the limestone was accumulating, and possibly during the beginning of the Rochester shale.

At Rochester this horizon, being a plane of subterranean drainage, has suffered considerable mineralization and dissolution. This is shown by numerous small cavities spanned by

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* The photographs reproduced as plates 27-30 were taken by Mr. George W. Kellogg, of Rochester. several of them under difficulties. The writer is greatly indebted to Mr. Kellogg's photographic skill and intelligent interest.

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TILDEN FOUNDATIONS

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From these [illegible] duced by [illegible] the process of [illegible] their construction [illegible] tunnel through [illegible] was accumulated [illegible] Rochester shale [illegible]

at Rochester [illegible] drainage, as [illegible] tion. This [illegible] needles of celestite, and the abundance of small spherules of marcasite. In the lenses themselves cavities filled with gypsum in four or five pound masses are common. At Niagara several of these cores have been found weighing from ten to fifteen pounds. [Pl. xxix, Fig. 6.]

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* The photographs [illegible]
[illegible] Rochester [illegible]
greatly [illegible]

The rock is apparently a structureless, exceedingly compact, dolomitic limestone, breaking with an imperfect conchoidal fracture. In color grayish blue, it weathers, like the including beds, to a light brown or yellowish hue.

Only by weathering is the true character of these masses clearly brought out, and a satisfactory explanation of their origin made possible. Then they prove to be mainly composed of a remarkable development of fistuliporid and other bryozoan forms, and to contain unusual accumulations of cephalopods, trilobites and brachiopods. Many of the species are rare or unknown in the surrounding limestone.

The lenses of Rochester alone have yielded, exclusive of the Bryozoa, which will probably add very materially to the number, sixty-eight genera, ninety-nine species and two varieties, disposed as follows:

CLASS.	GENERA.	SPECIES.	VARIETY.
Sponges	2	2	......
Corals	3	5	......
Crinoids	4	4	......
Cystids	1	1	......
Tubicolous Annelids	2	2	......
Brachiopods	29	36	......
Pelecypods	5	9	......
Gasteropods	5	7	......
Cephalopods	3	8	......
Ostracodes	1	1	......
Trilobites	9	10	2
Total	68	99	2

PREVIOUS OBSERVATIONS.

This phenomenon was observed by Dr. Eugene N. S. Ringueberg,* in Orleans and Niagara counties in the vicinity of Lockport and Gasport. He found them in restricted areas and of extremely variable thickness, appearing to be limited to the capping plane of the Clinton upper limestone. In view of the irregular and undulating appearance of the upper surface and the position of many of the fossils, he considered these bodies accumulations of organisms swept together by eddies and currents charged with the fine sedimentary matter in which we now find them. Dr. Ringueberg listed forty-eight species.

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*"The Evolution of Forms from the Clinton to the Niagara Group." Am. Nat., September, 1882, p. 711.

Prof. J. M. Clark under the announcement "Faunal Colonies in the Clinton beds,"* mentions the occurrence of these bodies in western New York through Orleans and Niagara counties. He describes them as lenticular masses of limestone ten to thirty feet in diameter and entirely disconnected, those in one plane lying imbedded in the midst of the Clinton limestone, though of wholly different texture and composition therefrom; in another, lying in the shale above the limestone and displacing or being surrounded by the lower shaly beds of the Niagara group (Rochester shales).

Amadeus W. Grabau, in his "Paleontology and Geology of Niagara Falls and Vicinity,"† under the heading "Limestone Lenses of the Clinton" says: "At intervals in the upper Clinton limestone may be seen large lenticular masses of compact, hard, apparently structureless limestone, often concretionary and not infrequently showing numerous smooth and striated surfaces of the type known as 'slickensides' and which are indicative of shearing movements."

He mentions the lenses in the Rome, Watertown and Ogdensburg railway cut under Lewiston heights, as entirely imbedded in the limestone from which they are differentiated by their structureless character. He also notes the mass seen in the New York Central railway cut on the side of the gorge near the third watchman's hut (see Fig. 6.) as lying between the upper limestone and the overlying shale, partially imbedded in both. He finds those under Lewiston hights rich in orthoceratites and shields of trilobites; and those of the gorge yielding chiefly brachiopods. From these lenses he lists twenty-eight species. Dr. Grabau observes that the origin of these lenses is still obscure.

THEORIES OF ORIGIN OF THE LENSES.

By Mechanical Agency: The presence of currents which would enmass such quantities of organic material in comparatively small spaces should have left other conspicuous struct-

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Report of the State Paleontologist for 1899 (pub. 1900).

†*Bulletin, N. Y. State Museum*, No. 45, vol. ix, April, 1901, pp. 99-102.

ural features, those observed being wholly disproportionate to the magnitude of the result.

The appearance of barren shale partings, going east from Niagara county, is evidence that the limestone making phase, dominant during the formation of these lenses, was interrupted by the incursion, from time to time, of mud-bearing currents from the shores of the eastern interior sea which lay to the north and east. Disarticulated brachiopods and dismembered, partially triturated, crinoidal remains, of which the including layers are composed, and occasional overturned Favosites found upon some of the surrounding limestone surfaces are regarded as other indications of currents. But the uniform thickness throughout different parts of the layers and their persistency, indicate that these currents were weak. Further, the remains of Bryozoa and other organic matter comprising these masses, often bulky of form, if enmassed by the impelling force of moving water would require strong currents or even wave action. But the absence of water-worn and broken shells within these masses, and of cross bedding and current channelings in the surrounding limestone is significant. This is strikingly illustrated by the beehive-shaped mass at Niagara gorge above the whirlpool. [Pl. xxvii, Figs. 5 and 6.] This heap of organic remains rises steep-sided eight or nine feet above the surrounding limestone surface, and nowhere either in or about the mass are the above conditions indicated.

The fine preservation of much of the organic material seems to point to its comparatively undisturbed condition after death; and the great number of rare forms, some not found outside of these masses, can hardly be credited to the sorting or selective power of currents or eddies.

There appears no reason to doubt that these masses were to some extent influenced by currents, but that any of them owe their origin wholly to this agent is improbable. The gentle movements of the water are regarded as only a modifying influence to some more important agent.

By Organic Growth: The explanation of origin is found in the bryozoan matter. The axes in all cases are large masses of fistuliporids. These organisms are always in position of growth, and practically do not occur outside of the lenses. That their position is normal is determined by examining their surfaces, and it is further proved by the great size of the concentric masses found in these lenses. This life once established, the growth keeping pace with or in advance of the slowly accumulating marl sediment, would through a long period of time produce essentially this phenomenon. That no other element is necessary is proved by masses bearing scarcely a trace of any other organism.

Great detached cores of this material often suggest, from their formal resemblance, great heaps of poorly mixed dough. Some growths with a fine sedimentary coating filling the pores, have the appearance of concretions, an impression which is hightened by the structureless character, usually revealed upon fracture. Concretions appear, however, to be entirely lacking in these lenses.

The indications are that these masses were not formed by the growth of any one colony but that the surfaces were constantly receiving accessions of new colonies springing up and spreading over the old detritus-laden surfaces, some of these frequently attaining considerable size. It appears from macroscopic examination of these surfaces, that two or three species of *Fistulipora* are represented, though but one is important as builder of these masses. The framework and bulk of all these lenses is seen to be bryozoan.

The irregularities of structure and outline observable in those masses is mainly the result of the influence of mechanical forces upon the bryozoan growth. Most important of these influences was the silt deposited during the muddy-water phases, indicated by the shale partings in the eastern portion of this area. The prominence of some of these masses undoubtedly enabled the currents to keep them partially free from silt, probably facilitated in no small degree by the life functions and activities of these living surfaces. Thus where the life was vigorous and considerably in advance of the floor deposit the sedimentation is seen to have had little effect. This is shown where shale layers perhaps three or four inches in thickness encroach but a little way or end abruptly at the side of a fistuliporid growth. [See left side of Fig. 1, Pl. xxvii.] Any loss of territory in this case appears usually to have been quickly made good by the more vigorous growth set up with the returning clear water conditions. Where the growth was weak and but little above the level of sedimentation, the silts are seen to have encroached from all sides and to have filled the depressions in the irregular surface [Pl. xxvii, Fig. 2], some times nearly or quite covering the mass. Usually these encroachments are one-sided, depending upon the configuration of the mass and possibly upon the direction from which the currents came. In such cases the surviving life, starting up afresh, is seen to have formed a new growth often quite distinctly defined and resting well over upon one flank of the parent mass. In many cases this was repeated several times, though not always so conspicuosly, the surviving life each time lying in a little different quarter. The limestone layers extending in upon these thin shale partings to the new life centers, are often flexed and thinned before being augmented by the local growth. [Pl. xxvii, Fig. 2.] Silt patches usually produce an imperfect layering within the lenses and sometimes recurring several times in the same vertical line, produce a bedding corresponding roughly with the planes of sedimentation without. Figure 1, plate xxvii, is of a mass which appears to be made up of two nearly independent growths of fistuliporids, with slightly diverging axes. The imperfect layering in the space between the two halves, was maintained by silt pocketing.

In some instances life may have been completely smothered out and the elevation remaining became later the site for new fistuliporid colonies. This is difficult to determine, owing to some part of the mass always being broken away or remaining imbedded. Of two neighboring masses, on the Genesee, the growth of one is seen to have stopped at a certain silt plane, while the other is divided by it into distinct upper and lower portions. It is the impression however that there must have been some life connection between the two growths.

Another mass at the same locality had somewhat the shape of an hour-glass. The narrow neck of lens rock which connected these two parts or lenses, probably represented the thread of life surviving the silt girdling. This life at last regaining vigor and extent was finally smothered out by another and heavier blanket of fine mud, indicated by the shale which covers its summit.

The presence of silt, where not sufficient to smother the growing surface, seems in some cases to have caused the bryozoan growth to enroll and knot in an unusual degree.

The growth of new colonies upon these surfaces, the silt encroachments and consequent shiftings of growth and concurrent irregular bedding, all combined to produce some very complex structures. But the life of these masses passing roughly through a maximum to a decline, the resulting form is nevertheless always sub-lenticular.

Currents evidently played an important part in the disposal of the lighter material growing upon and about these sites. This is proved by the contents of the rim-like thickenings sometimes observed, where a limestone tier abuts a fistuliporid growth, which was in advance of the plane of sedimentation. The thickening (A) on the left side of the well-defined fistuliporid head [Pl. xxvii, Fig. 2.] is made up of fragments of delicate funnel-form and dendritic bryozoans, disarticulated brachiopods and crinoidal fragments. The bryozoan material growing less and finer a few feet out from the mass, and its abundance upon these sites, indicate its source. The crinoidal rubble being more abundant farther out upon the slope, suggests that this material was drifted from outside. Crinoids evidently grew very abundantly over the level floor, their remains contributing more than anything else to the formation of the including strata. A remarkable thickening, made up mainly of crinoidal fragments, is seen on the eastern side of a mass east of the station at Lewiston hights. Currents approaching or leaving these masses appear in either case to have added to these marginal deposits. Some of the rock formed from the light, portable material collected in this way suggests Coquina limestone after the fine filling is weathered out.

An interesting problem is presented by two masses on the Genesee which stand so near together that their inner margins are scarcely five feet apart. One, six feet in diameter, is composed almost wholly of fistuliporid material with scarcely a trace of crinoids; the other, twenty-five feet in diameter, and starting at the same level, is made up in the peripheral portion almost exclusively of crinoidal debris. This suggests that the latter had a fringing colony of crinoids.

Where sedimentation was nearly apace with the bryozoan growth, the fistulipora, by repeated extensions over the fragmental matter collecting upon its margins, often formed an interweaving so complete that the passage from the mechanical deposits to those of life-growth is difficult to determine.

In the masses where the lighter material was particularly abundant, a slight shifting has resulted in an imperfect layering, and sometimes encumbering the surface which must have interfered nearly as seriously with the fistuliporid growth as did the silt.

From the small size of these masses and the manner in which the lighter material is disposed about them it is seen that they could not have been an important source for the supplies of organic matter which compose the including limestone strata.

Though many forms of life appear to be especially associated with the peculiar conditions found upon these sites, yet many others found here are cosmopolitans. The level floors were evidently richly covered with life, though not comparing with the luxuriance of these tumuli and their immediate neighborhood. Some forms seem to have preferred the level stretches just as others preferred the fistuliporid sites. It is probable however that with favorable conditions for preservation the level floor would be found to include them all; as primarily it must have been the source. More extensive collections will do much to clear this point. When we compare the contents of different layers of a stratum which vary considerably among themselves in their assemblage of forms with the contents of the lens-rock proper we find that the principal form or forms of a given layer are oftentimes not shared by the lenses at or above that particular level. For example in Rochester a ten-inch layer, the thickest in the upper six feet of this limestone, abounds in *Whitfieldella naviformis*. This layer abuts, and in many cases fuses with, lenses, yet rarely is this brachiopod found in them.

Weathering brings out the organic features though slowly and superficially. A lens partially blasted away in 1885, in the extension of a sewer down to the water level of the Genesee, has weathered so far as to show how completely the mass is made up of Fistulipora, but under a blow of the hammer, the

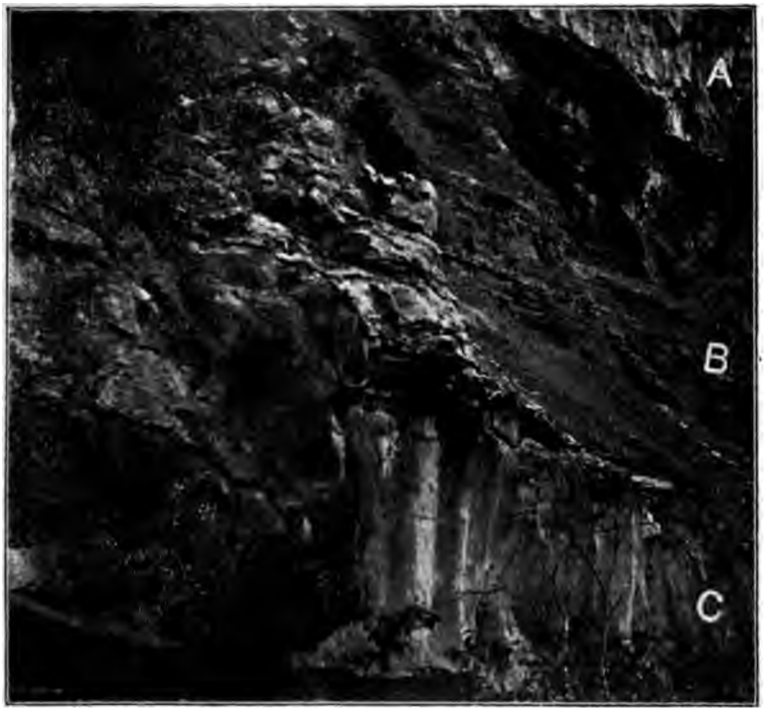

FIG. 4. Beehive-shaped mass, 10 feet high, starting in the upper massive bench, C, of the Clinton upper limestone, and reaching up into the Rochester shale, B, about 8 feet. A, Lockport limestone.

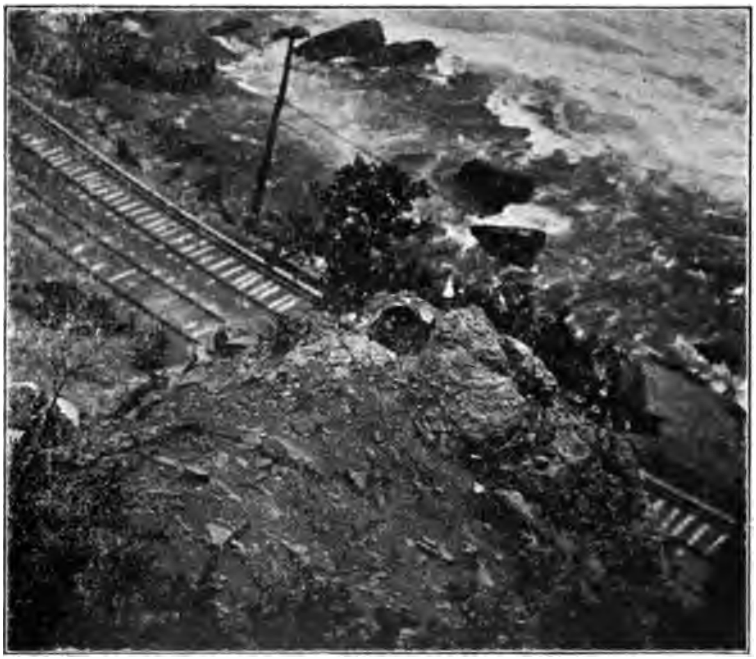

FIG. 5. Same mass as Fig. 4, seen from above.

REEF IN NIAGARA GORGE.
About one-fourth mile above whirlpool.

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ASTOR, LENOX AND TILDEN FOUNDATIONS

rock splinters reveal a structureless bluish gray surface, with no trace of organic contents.

The lenses at Niagara and vicinity generally exhibit a more uniform aspect than those in the eastern portion of the area, due to the smaller percentages of silts, the upper ten feet at that locality forming a solid bench. [Pl. xxviii, Fig. 4.]

Owing to the well defined bedding planes in the limestone at Rochester, [Pl. xxvii, Figs. 1 and 2.] these features may all be studied there to particular advantage, affording an unequaled opportunity for comparisons. It is possible to trace any of the shale partings from one neighboring mass to another, thus enabling one to see its relation to several of these growths, or to examine several limestone floors in their vicinity in the same way.

While these masses were similarly affected by general conditions yet in each we find many features that are specific; showing that each lens had a history differing from that of every other.

ASSOCIATED LIFE.

Attached Forms:—The associated life usually found upon these fistuliporid masses shows them to have been mainly centers for other attached forms. This is probably due to the fact that the free larva of the smaller and more delicate bryozoans, and of brachiopods in particular, required some firm base for attachment. Freely distributed in the sea, they settled everywhere, but lived in greater numbers upon these hard surfaces, there finding this prime essential to their existence. One of the best examples of this is found in Niagara gorge on the New York Central and Lewiston railroad, at the third watchman's hut. [Pl. xxix, Fig. 6.]. This mass is thirty feet long and ten feet high. Brachiopods probably make as high as thirty per cent. of the contents. In some parts their shells are so abundant as apparently to have nearly smothered out the bryozoan nucleus. In the mass proper the brachiopods are entire and appear to have been largely covered by the bryozoan growth, thus preserving the valves intact. Some of these are evidently in position of growth.

Other Forms:—Thus inhabited these sites attracted other forms which in turn drew others, until they became rich feedtinued for some time to be the center for attached forms. Brachiopods are remarkably abundant in the basal portion and comparatively rare in the upper. This mass also contains several trilobite pockets. The accompanying sketch shows roughly the arrangement of the various elements as displayed in the present section of the mass. From the configuration of the beds beneath on the right side and their slope, it is evident that the portion of the mass broken away extended considerably lower on that side. The extinction of the life of the mass probably occurred about the time the silts reached the level on its sides, indicated by their extension over its top.

The other cases of growth upward into the shale are along Genesee. The upper two or three feet of these masses are made up mainly of an irregular, dome-like, fistulioporid growth, discolored with sedimentary matter, of the same appearance as that of the enclosing base of the Rochester shale. Their life was short after the introduction of the shale sediments.

The conditions for the continued growth of these masses in the shallowing turbid waters of the sea at the opening of the Niagara epoch seem to have been adverse, though more favorable in the western portion of the area. The most injurious was the rapid accumulation of calcareous mud which undoubtedly interfered seriously with the continued local growth of the bryozoan life. This effect is shown in the study of these masses in the limestone where the incursions of mud-bearing currents reduced the growing surfaces which again extended on the return of clear water conditions. The same fistuliporas in the shale never attained a growth exceeding a few inches radius.

COMPARISON WITH EXISTING PHENOMENA.

The fragmental character of the material forming the Clinton upper limestone at the level of these masses, makes it probable that these layers were deposited at a depth slightly within wave-base. The depth can hardly be estimated from assuming a similarity of conditions in any existing sea or bay, for the data available on this subject are found to be discordant. It was probably considerably within the one hundred foot line, a depth consonant with the more vigorous marine growths of to-day.

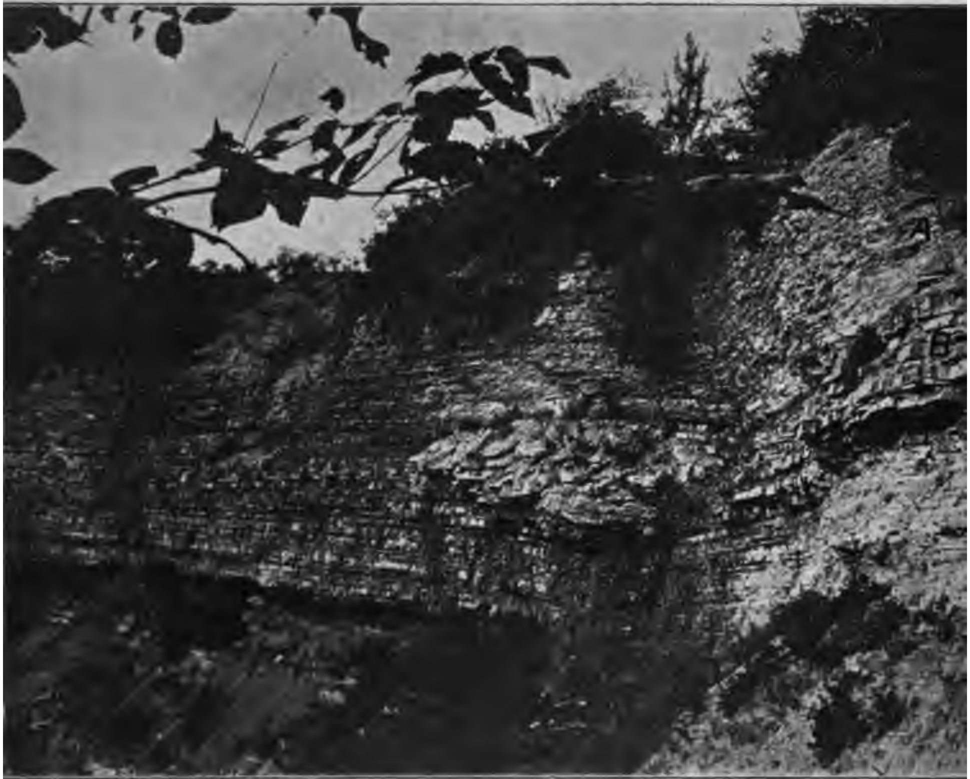

FIG. 7. Lens in Rochester ravine, 150 yards north of east end of Seneca Park Bridge. Dimensions 1 feet. A—Rochester shale; B—upper bench of Clinton upper limestone.

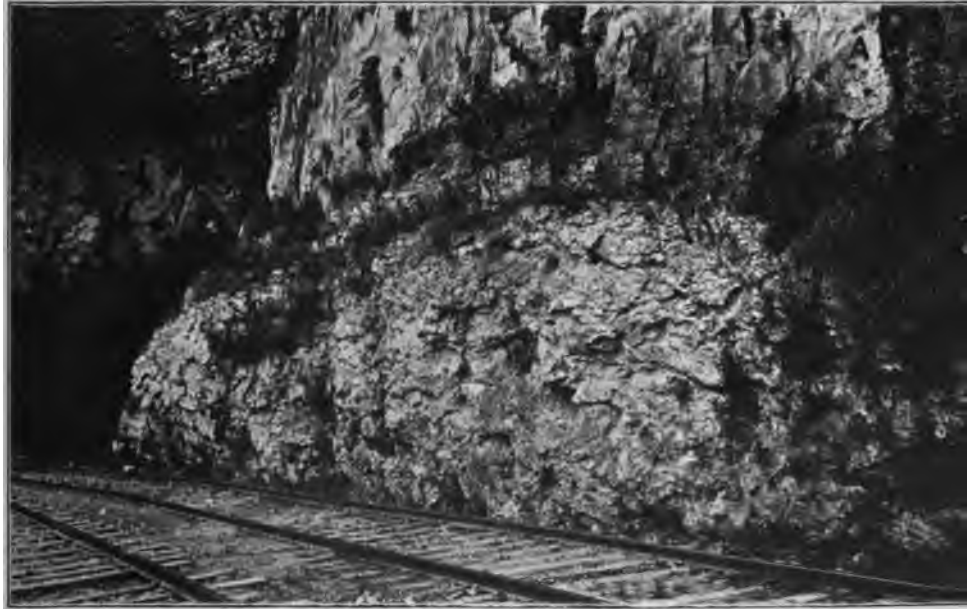

FIG. 8. *Reef in* Lockport limestone, Niagara gorge, one-half mile above Suspension bridge, Electric (Gorge) R. R. Length 110 feet; hight exposed, about 12 feet.

REEF STRUCTURES.

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ASTOR, LENOX
TILDEN FOUNDATIONS.

Thus these colonies of *Fistulipora* with the associated life drawn about them by the very favorable conditions affording attachment, food and shelter, are seen to have formed low, irregular, dome-shaped prominences, upon the broad, level, floor of a shallow sea. They are not known to have ever reached an elevation exceeding ten feet, the approximate hight of the largest yet known. A mass about one-fourth of a mile above that at the third watchman's hut, was estimated to be fifteen by fifty feet.

Their distribution we have seen was irregular, sometimes isolated, oftener in groups covering considerable areas, or, as in one known instance, coalescing to form an extended layer.

In this ancient coral-maker* (for professor Agassiz considers the bryozoan animal such) and the rich concourse of associates indicated, we find life conditions according so well with those observable in the modern reef or coral-field, as described by Darwin, Dana, Agassiz and Kent, that no hesitation is felt in pronouncing these to be ancient coral reefs. While having many of the features common to such structures in general, these little reefs present a more striking analogy to a peculiar kind described as follows by professor Charles F. Hartt:† "So far I have only spoken of fringing reefs, but there are other coral structure of greater interest in these waters. Corals grow over the bottom in small patches in the open sea, and, without spreading much, often rise to the hight of forty to fifty feet or more, like towers, and sometimes attain the level of low water, forming what are called on the Brazilian coast 'chapeiroes', (signifying, big hats). At the top these are usually very irregular, and sometimes spread like mushrooms, or, as the fishermen say, like umbrellas. Some of these chapeiroes are only a few feet in diameter. A few miles to the eastward of the Abrolhos is an area, with a length of nine to ten and in some places a breadth of four miles, over which these structures grow very abundantly, forming the well-known Parcel dos Abrolhos, on which so many vessels have been wrecked." Professor Hartt in describing a visit to the northwestern part of this reef, mentions, among other facts: "The chapeiroes, as a general thing, are rarely ever laid bare by the tide." "They are here, as elsewhere, of all hights and dimensions." * * * "They do not coalesce here as elsewhere, to form large reefs as they do in the rest of the islands."

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*There is much difference of opinion regarding the position of these fistuliporids. Some are inclined to consider them corals.

†*Geology of Brazil*, 1870. pp. 199-200; also p. 191.

Professor James D. Dana says of their structure: "The rock of these submerged coral-heads is but a loose aggregation of corals in the position of growth, except possibly, in their lower portion, where the open spaces may be filled with sand and fragments cemented together."

SIMILAR OCCURRENCES IN OTHER GEOLOGIC HORIZONS.

Lockport (Niagara) Limestone.—At Niagara gorge, about one-half mile above (south of) the suspension bridge and one hundred yards north of where the Gorge railway reaches the open face of the ledge beside the track, and at a level twenty or twenty-five feet above the base of the Lockport limestone, is a reef [Pl. xxx, Fig. 8] one hundred ten feet in length and exposed to the hight of twelve feet. It lies in a thin-layered stratum of limestone separating two massive benches. The irregular structure of the reef is in contrast to the thin-layered limestone, while the upper massive bench is arched over it. The reef rock is a compact bluish dolomite, weathering to a yellowish hue. Bryozoans are abundant, often in masses of considerable size, but owing to the comparatively recent date of the railway cutting weathering has done little to bring out other organic contents. It is probable that this mass originated in the same manner as those of the Clinton upper limestone. Other reef masses are conspicuous at this level along the gorge. One seen just north of the eastern end of the cantilever bridge is two or three hundred feet long.

Seventeen miles eastward along the Niagara escarpment and three miles west of Lockport, in a road-cutting, three well weathered masses are exposed at the same level. [Pl. xxxi, [illegible]] The first thing that arrests the eye is the loose structure of these masses, strongly contrasted with the firm beds of [illegible]. This, coupled with the remarkable assemblage of [illegible] forms of bryozoans, corals, crinoids, brachiopods and [illegible] in a better state of preservation than the organic [illegible] limestone of enclosure, favors the conclusion that [illegible] we have another example of reefs.

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*Corals and Coral Islands, 1872, p. 142.

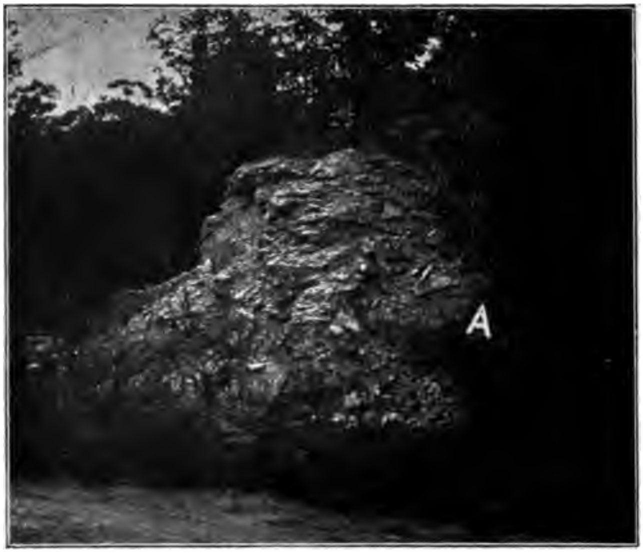

FIG. 9. Mass by highway, 3 miles west of Lockport.

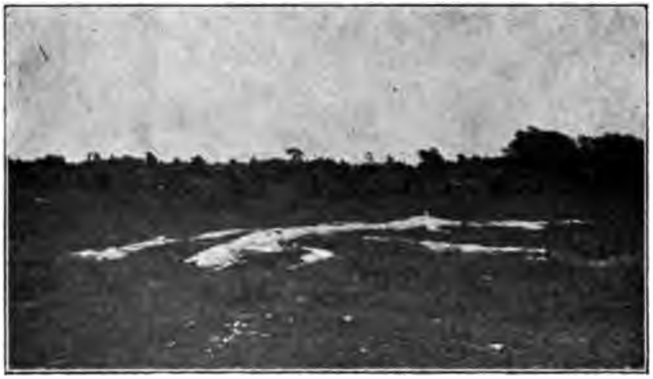

FIG. 10. Reef appearing above the soil in a field in the western edge of Lockport.

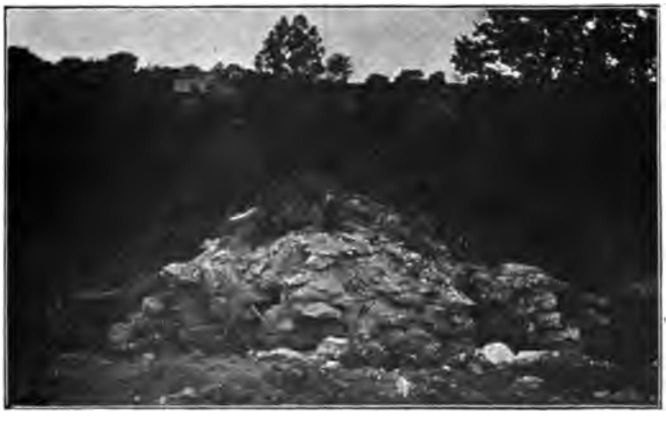

FIG. 11. Reef appearing in quarry, north side of N. Y. C. R. R., about one and one-half miles west of Lockport station. Diameter 24 feet.

REEF STRUCTURES IN LOCKPORT LIMESTONE.

where, of all hights and dimensions." * * * "They do not coalesce here as elsewhere, to form large reefs as they do to the west of the islands."

Professor James D. Dana says of their structure: "The rock of these submerged coral-heads is but a loose aggregation of coral in the position of growth, except possibly, in their lower portion, where the open spaces may be filled with sand and fragments cemented together."

SIMILAR OCCURRENCES IN OTHER GEOLOGIC HORIZONS.

Lockport (Niagara) Limestone:—At Niagara gorge, about one-half mile above (south of) the suspension bridge and one hundred yards north of where the Gorge railway reaches the open face of the ledge beside the track, and at a level twenty or twenty-five feet above the base of the Lockport limestone, is a reef [Pl. xxx, Fig. 8] one hundred ten feet in length and exposed to the hight of twelve feet. It lies in a thin-layered stratum of limestone separating two massive benches. The irregular structure of the reef is in contrast to the thin-layered limestone, while the upper massive bench is arched over it. The reef rock is a compact bluish dolomite, weathering to a yellowish hue. Bryozoans are abundant, often in masses of considerable size; but owing to the comparatively recent date of the railway cutting weathering has done little to bring out other organic contents. It is probable that this mass originated in the same manner as those of the Clinton upper limestone. Other reef masses are conspicuous at this level along the gorge. One seen just north of the eastern end of the cantilever bridge is two or three hundred feet long.

Seventeen miles eastward along the Niagara escarpment and three miles west of Lockport, in a road-cutting, three well weathered masses are exposed at the same level. [Pl. xxxi, Fig. 9]. The first thing that arrests the eye is the loose structure of these masses, strongly contrasted with the firm beds of inclusion. This, coupled with the remarkable assemblage of Niagara forms of bryozoans, corals, crinoids, brachiopods and other types, in a better state of preservation than the organic materials comprising the limestone of enclosure, favors the conclusion stated, that here we have another example of reefs.

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*Coral and Coral islands, 1872, p. 142.

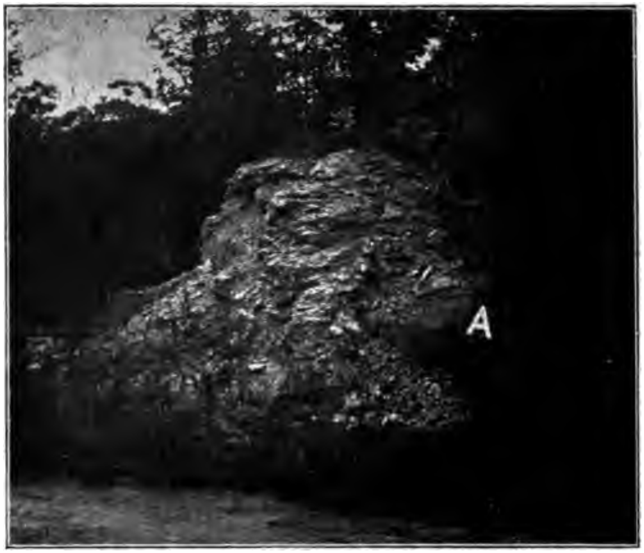

FIG. 9. Mass by highway, 3 miles west of Lockport.

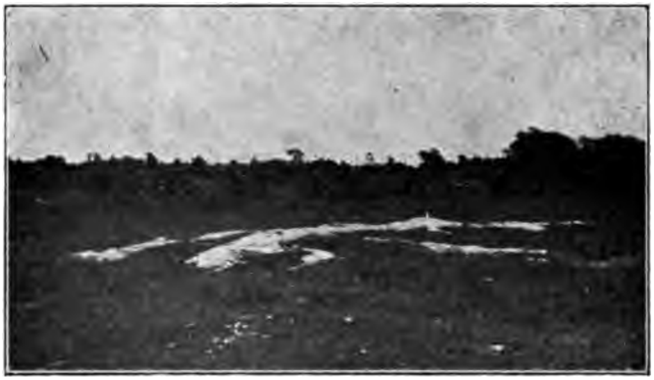

FIG. 10. Reef appearing above the soil in a field in the western edge of Lockport.

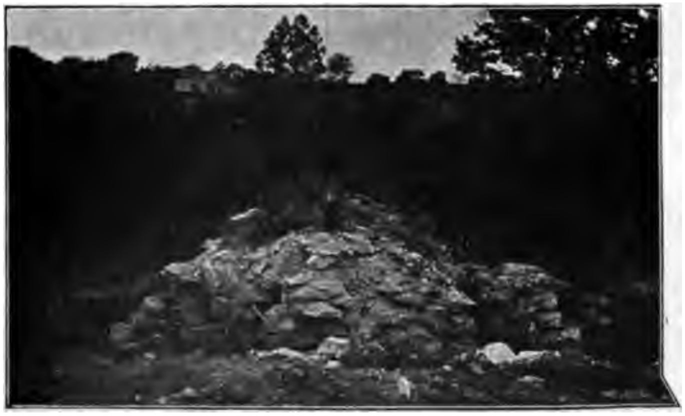

FIG. 11. Reef appearing in quarry, north side of N. Y. C. R. R., about one and one-half miles west of Lockport station. Diameter 24 feet.

REEF STRUCTURES IN LOCKPORT LIMESTONE.

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TILDEN FOUNDATIONS.

Dr. Ringueberg recently directed the writer's attention to a field in the western outskirts of Lockport in which a dozen or more small patches of rock project through the soil, in low, dome-like prominences [Pl. xxxi, Fig. 10]; and expressed the opinion that they are of the same nature as the masses of the Clinton. A visit to the locality corroborated this opinion. At one side of a quarry in this lot, the uneven character and the thickening of the beds abutting a mass, may be seen. The crest of the reef itself appears a little farther back. Its form evidently is ridge-like. Its position may be traced for eighty-eight paces by an overlying crest of upturned rock edges passing into a ridge of soil, fading out with the increasing depth of the drift. Another reef has been blasted through in forming a roadway from this quarry.

Five other examples, left completely isolated by the removal of rock, were found in a neighboring quarry. One of these has been partially destroyed, leaving only the basal portion; two stand in relief upon basin-shaped pedestals of limestone [Pl. xxxi, Fig. 11]; one, ridge-like and extending in the same direction as the mass of similar shape described above, has been traced thirty-one paces to its disappearance under the embankment of the Falls Branch of the New York Central railroad; one fuses into the quarry floor, which slopes gently from it, a ridge-like rounding of this limestone surface on one side, forming a continuation of the long axis of the reef. This surface shows the configuration of the old sea floor in the vicinity of the reef. The hard, compact structure of this floor is in marked contrast to the loose shaly nature of the weathered reef rock. Another quarry in the vicinity has afforded five more. The electric road from Tonawanda to Lockport cuts through this level, exposing two reefs.

Some of the reefs observed must start almost upon the impure concretionary base of the Lockport limestone, others fifteen to twenty feet higher. The largest is that at Niagara gorge, at the cantilever bridge.

This horizon includes the encrinal band and perhaps the lower portion of the Coralline limestone described by Hall. They may extend still higher. for professor Hall* describes a mass and accompanying arching of the strata, as occurring

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**Geol. 4th District, N. Y.*, p. 92.

two miles south of Lockport on the Erie canal. His explanation was that the mass was the result of mineralization. The encrinal band may be traced into western Monroe county before its characteristics entirely fade. No search for reefs has been made in this quarter as yet, and the cursory examination given the outcrops between here and Niagara gorge has failed to reveal others.

Two of the masses west of Lockport have been known to the writer several years, but their nature was not clear until they were observed at Niagara gorge in connection with the reef structures of the Clinton.

Bryozoans form the main constructional element of these old reefs. One of them exposed in the quarry on the eastern bank of the Niagara, a short distance south of the third watchman's hut, is forty-five feet long and nearly a solid mass of fistuliporids. Crinoids are nearly or quite as important in some cases as the Bryozoa. The *favosite* and *heliolite* corals are sometimes important builders.

The peculiar groupings of special forms are as marked a feature here as in the reefs of the Clinton. Some of them are remarkable for their general assemblages, but in most cases at various stages in the growth, or at various points upon these masses and occasionally throughout their entire formation, certain forms predominate or occur in unusual numbers. Sometimes they are corals, delicate branching bryozoans, trilobites or cephalopods.

It is noticeable that a number of species, mainly brachiopods and trilobites, common in the Clinton reefs, nearly one hundred feet lower, are found here.

These masses in the Lockport limestone of western New York find their counterpart in lithological character, fossil contents and stratigraphic position, in the reefs described by Dr. Chamberlin[1] in the Waukesha and Racine beds of the Wisconsin Niagara. These structures were found to form a barrier [illegible] miles in length. From them two hundred species [illegible] been obtained.

Dr. Chamberlin calls attention to a feature which we have [illegible] in the reefs of New York, viz. a tendency of the [illegible] to collect in groups of special forms, which reaches its most striking development among these reef forms. This he speaks of as "Colonial Tendencies."†

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[1] *Geol. of Wis.*, vol. i, 1873-1879, pp. 183-186; and *Geol. of Wis.*, vol. ii, 1873-1877, pp. 169-71.

Dr. Robert Bell‡ has described great cavernous masses of limestone occurring in thin bedded, nearly barren limestone of Devonian age, on the Attawapishkat river, Canada. They are made up of a few species of fossils including corals. These from their form and contents suggest our reefs of the Clinton and Niagara.

Dr. G. K. Gilbert and F. P. Gulliver§ describe the cores of the Tepee Buttes of Colorado, as hard squamous masses of limestone of elongate cylindrical form, resting in the soft shales of the Fort Pierre Cretaceous. The authors are inclined to regard them as formed by colonies of *Lucina occidentalis-ventricosa,* of whose remains they are mainly composed. From their having so many features in common with the masses described by Dr. Bell, they regard their close relationship unquestionable.

A SCHEMATIC STANDARD FOR THE AMERICAN CARBONIFEROUS.

By Charles R. Keyes, Des Moines, Iowa.

In the attempts to parallel, in America, the various subdivisions of the Carboniferous, there has always been more or less difficulty in securing results that are even approximately satisfactory. The sections of the East, of the Interior, and of the West, appear at first glance to have no comparable elements. In consequence, the eastern, or Pennsylvania, succession, having been the first to be carefully studied, has come to be regarded as the section to which all others of the continent must be eventually referred. As for the rest of the continent, little consideration is given it so far as concerns any serious effort to establish general sections with which all others in each province might be compared, and which in its serial subdivisions, at least, could be arranged with reference to a schematic section.

One main reason for this rather anomalous state of the subject is, of course, the fact that the boundaries between the several provinces of the Carboniferous are, as yet, nowhere carefully determined. Separating the exposed areas are broad stretches of country in which practically none of the younger Paleozoics are represented in outcrop. Another consideration is the fact that the formational units established in the various districts, have been largely local in nature and tentative. They are now known to possess widely different taxonomic values, hence permitting only very vague stratigraphical correlations to be carried on. A third feature is one which has been thought by many workers to render all attempts at paralleling horizons useless, and is the diversity of origins which the sediments present. The marine nature of the deposits in one province, as in the Rocky Mountain region for example, and the general presence of littoral conditions at the time the formations were laid down in other regions, as in the Appalachians, would seem to almost preclude comparison.

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†*Ibid*, pp. 184-196,

‡*Geol. and Nat. Hist. Survey of Canada, Ann. Rept*, vol. ii, (1886), pp. 27G, 28G.

§*Bull. Geol. Soc. Am.*, vol. vi, pp. 333-342, part 17.

In the Mississippi valley, however, there are all of the several kinds of conditions of sedimentation well represented. The marine deposits alternate with off-shore and coastal sediments. Not only do the different kinds of formations alternate, but many extensions of those from the west interlock with those from the east. During several distinct epochs the sea encroached upon the domains of the coastal deposits. At other times the coarse land-derived materials were carried far out into areas where more open-sea conditions had previously prevailed. In the general vertical section of the Mississippi valley, or more specifically that of the Ozark region, where is perhaps the best representation of strata, is believed to exist a record that in all respects sufficiently approaches both that of the East and that of the West, to enable it to be made useful in the exact correlation of the serial relations of the Carboniferous of the whole country. The relations of this succession of formations is such that from it, it appears possible to construct the schematic section of the Carboniferous for the entire American continent.

The chief merit of the general Ozark section of the Carboniferous as a standard of reference is its exceptional completeness. No other section of the Carboniferous rocks on the American continent possesses such an enormous thickness.

The series of the system appears to be more sharply defined than anywhere else. Few sections have the base so abruptly cut off from the Devonian below. At the top the Cretaceous strata often rest upon it in marked unconformity.

Instead of trying to make the Mississippi valley section fit that of Pennsylvania, as heretofore has always been done, effort would be far more fruitful of satisfactory results by bringing the rock succession of the latter into accord with the former. In place of attempting to extend the Mississippi sequence to the region of the Rockies, the formations of the latter should be apposed to those of the first mentioned. In other words, a direct and complete reversal of present methods of comparative procedure is recommended as the first step in the solution of the intricate problems of correlation presented.

The critical criteria for bringing the general sections of the various provinces into harmony with a general schematic section for the continent must be very different from those which have been long in use. The fossils have not only failed to give exact results, but it is now known that in many cases their several elements actually admit of no logical camparisons. The comparisons of the floras have been more satisfactory, so far as they have gone, but they have been necessarily limited; and as yet there have been no means of checking these readings.

A review of the work of the last fifty years clearly demonstrates that in correlating strata, the testimony of the fossils does not give the results expected of them. For exact correlation, we must turn to other standards. In the physical history of a region the most hopeful outlook is presented.

In comparing faunas which are marine in one province or region, brackish in another, littoral elsewhere, there are few or no common factors that can be readily utilized. In order that the real significance of the varying features may be understood, the fossils demand vastly more study than can ordinarily be given them in a short time. The sought for information is therefore usually obtained from other sources long before the fossils are able to yield it up. The methods of physical correlation of strata have now become so advanced that the results are highly satisfactory and exact to a remarkable degree, even between rock successions of different provinces. Even the principle of orotaxial correlation* is found to be so nicely applicable† tnat its wider extension must be productive of results wholly unlooked for.

A general section of the Carboniferous of the Mississippi valley is as follows:

GENERAL GEOLOGICAL SECTION OF THE CARBONIFEROUS OF THE MISSISSIPPI VALLEY.

	SERIES.	TERRANES.	THICKNESS FT.
CARBONIFEROUS SYSTEM.	*Cimarron*	Kiger shales	250
		Salt Fork shales	500
	Oklahoman	Wellington shales	200
		Marion limestones	150
		Chase limestones	200
		Neosho shales	150
	Missourian	Cottonwood limestone	10
		Atchison shales	500
		Forbes limestones	30
		Platte shales	150
		Plattsmouth limestones	30
		Lawrence shales	300
		Stanton limestones	35
		Parkville shales	100
		Iola limestones	50
		Thayer shales	75
		Bethany limestones	100
	Des Moines	Marais des Cygnes shales	250
		Henrietta limestones	75
		Cherokee shales	300
	Arkansan	Sebastian	1800
		Spadra	500
		Norristown	400
		Boonville	2500
		Appleton	1300
		Danville	2000
		Millstone grit .	500
	Mississippian	Kaskaskia	200
		St. Louis	300
		Augusta	250
		Chouteau	100

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*AMERICAN GEOLOGIST, vol. xvii, 1896, pp. 289-302.
†*Bull. Geol. Soc. America*, vol. xii, 1901, pp. 173-196.

In the Mississippi valley section, the dividing lines between the several series are horizons which are probably capable of being very much more widely traced than has yet been attempted. Most of the planes separating the series are natural stratigraphic horizons. They are located at levels where marked changes in sedimentation have taken place, where new phases of geological history begin, where lithological differences were brought into strong contrast. Decided orogenic changes of a rather abrupt nature took place at the times represented by these boundary lines of the series.

The subdivisions of the series are of minor importance in the present connection. Whatever might be these values in the Mississippi valley they would necessarily have few or no elements of exact comparison with those of other geological provinces.

The attempts to parallel the Mississippi valley section of the Carboniferous with that of Pennsylvania have been not only uniformly unsatisfactory, but on the whole manifestly more or less fanciful. With the Mississippi section now so well determined, with its subdivision meaning something more than mere convenient groupings of strata, and with the extension of the scheme westward, the Ohio and Pennsylvania sections come to have a significance that was wholly impossible to ascribe to them before. Of course with the present nomenclature and present divisional lines the terranes can be compared only as approximate equivalents.

Graphically represented, the serial terranes of the Carboniferous system have, according to the best information we have, something of the following relationships and developments, shown in the subjoined cut (Fig. 1):

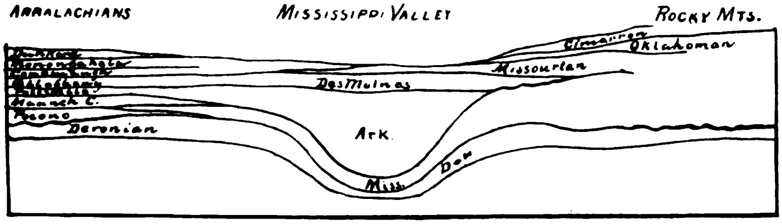

FIG. 1. RELATIONSHIPS OF THE CARBONIFEROUS SERIES IN AMERICA.

In the East and in the West the base of the Carboniferous system appears to be well defined on account of the presence of marked unconformities. The depositional equivalents of these great erosional breaks in sedimentation have never been suggested or sought for. What they represent in terranes would be of greater interest to know. They may have been formed while very considerable deposits were being laid down as Carboniferous formations. The horizon of unconformity might then be separated from the real base of the Carboniferous by a stratigraphical interval of very considerable extent. As an analogous illustration of what vast possibilities might occur, even in the Carboniferous system itself, the Arkansan series of the Ozark region may be cited.*

In the Mississippi valley there appear to be no indications of the existence of unconformable relationships between the beds called Devonian and those termed Carboniferous. The succession so far as is now known is unbroken and the sediments are of marine origin. For this reason a Devonian facies of the fossils may have been retained in this region long after the Carboniferous was fully inaugurated in other provinces.

The problems which arise for solution in this connection are many; and their definite formulation is of fully as much importance as the recognition of the fact that they exist.

As a terrane, or structural unit the typical Mississippian series can be probably never exactly extended into the eastern provinces or into the western districts. In the first named direction terranes of very different lithological composition replace it. In the second direction there must be for a long time yet difficulty in separating it from lithologically similar formations above, through the whole sequence of which the succession of faunas is unbroken and must change very gradually. Just how much of the Pocono and Maunch Chunk formations of the Pennsylvania section which are commonly regarded as forming the Lower Carboniferous, is the stratigraphic equivalent of the Mississippian must depend upon some further exact work of correlation in the region occupied by Kentucky and Indiana. The same is true, to a less degree, of the Ohio section. At present, it seems probable that a part of the Waverly will be found to belong more properly to the Devonian.

In the east, the Mississippian appears to be replaced by at least two terranes of as yet indeterminable vertical extent

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Bull. Geol. Soc. America, vol. xii, 1901, p. 179.

and wholly different in origin from it. On the other hand, in the west the marine deposits, which must be its equivalent, merge above with the later Carboniferous formations of like origin and lithological character. With no shore representatives in the west between the marine Mississippian and the marine Missourian formations, and the rock sequence being unbroken, the marine facies of the Arkansan and Des Moines are important features for determination.

While westward the littoral formations known in the Mississippi valley as the Arkansan and Des Moines series have no representatives of like origin, their eastward extension is not so difficult to follow. The Arkansan, so enormously thick in the typical locality, thins out rapidly eastward. Although its exact equivalents have not been carefully followed through Kentucky, Indiana and Ohio to Pennsylvania, it seems that it may be regarded as probably representing very nearly the interval occupied by the Pottsville in the last mentioned state. This interpretation has additional weight on account of the fact that all present evidence goes to indicate that the Allegheny series of Pennsylvania and the Des Moines series of the Mississippi valley are about equivalent stratigraphically. The late floral determinations of White* also go to support this statement.

Of the Pennsylvania section the interpretation advanced would make the Conemaugh and the Monongahela, and probably also the Dunkard (so-called Permian) littoral and coastal representatives of the Missourian; for it is not now believed that any part of the so-called Permian in Pennsylvania is so high stratigraphically as the base of the so-called Permian of Kansas.

It is not thought that the Oklahoman has any depositional equivalents in the east. Until recently it was believed that the Cimarron or Red Beds of Kansas would eventually prove to belong to the Triassic or Cretaceous, but late information seems to show that the formation doubtless is a part of the Carboniferous.

U. S. Geol. Sur., Mon. xxxvii, 1899.

THE TORONTO AND SCARBORO' DRIFT SERIES.

By Warren Upham, St. Paul, Minn.

Among all the North American localities of interglacial deposits, Toronto and Scarboro', situated close together on the northwestern shore of lake Ontario, present questions of the greatest interest and importance in their relation to the changes of climate attending the decline and end of the Ice age. The complex drift series of these localities, including alternate formations of till and fossiliferous freshwater beds, has been described, with discussion of their climatic significance, by Hinde,[*] Coleman,[†] Chamberlin,[‡] and the present writer.[§]

It will be needful, therefore, to give in this paper only a general statement of the drift sections and their remains of the Late Glacial fauna and flora. The chief purpose will be to inquire what these imply concerning the conditions that here permitted several alternations of glacial and interglacial beds, and to learn whether they indicate a far retreat of the border of the ice-sheet, worthy to be called a distinct interglacial epoch, or were records of moderate oscillations of the ice border, being then referable wholly to minor stages in the closing Champlain epoch of our continental glaciation.

According to the view presented by Chamberlin, in 1894, the Toronto interglacial beds are referred provisionally to a long interval between the Iowan and Wisconsin stages or epochs, giving to them a large epochal significance. They would thus denote a prolonged time of greatly diminished area of the continental ice-sheet, or its complete disappearance, succeeded by renewed far advance, if not indeed wholly new accumulation, of the vast ice-fields. Hinde, writing much earlier, gave a nearly equivalent opinion; and Coleman, in his subsequent papers, agrees with Chamberlin, though the observations noted seem to be favorable to the opposite view which I suggested partly and imperfectly in 1895, in the paper before cited, and which, by the more ample data since published, I will here endeavor to support more fully.

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[*] G. J. Hinde, "The Glacial and Interglacial Strata of Scarboro' Heights and other localities near Toronto, Ontario," *Canadian Journal*, vol. xv, pp. 388-413, April, 1877.

[†] A. P. Coleman, "Interglacial Fossils from the Don Valley, Toronto," American Geologist, vol. xiii, pp. 85-95, Feb., 1894; "Glacial and Interglacial Deposits near Toronto," *Journal of Geology*, vol. iii, pp. 622-645, Sept.-Oct., 1895; "Glacial and Interglacial Beds near Toronto," *Jour. of Geol.*, vol. ix, pp. 285-310, May-June, 1901.

[‡] T. C. Chamberlin, "The Toronto Fossiliferous Beds," in chapters contributed to Prof. James Geikie's Great Ice Age, third edition, 1894, pp. 765-769; "The Classification of American Glacial Deposits," *Jour. of Geol.*, vol. iii, pp. 270-277, April-May, 1895.

[§] "Climatic Conditions shown by North American Interglacial Deposits," Am. Geologist, vol. xv, pp. 273-295, with map, May, 1895.

My interpretation of the history recorded by this drift series in and near to Toronto and Scarboro' refers it to minor climatic vicissitudes during a late part of the Wisconsin or Champlain epoch. Under either view the alternating glacial and interglacial beds belong to the last third, and most probably even to the last tenth, of the Glacial period; and my explanation places them indeed very near to its end, in companionship with the great glacial lakes Agassiz, Warren, Algonquin, and Iroquois.

Details of the sections of this series, and lists of the fossils in its interglacial deposits, have been given by Hinde in 1877, and by Coleman in his several papers of 1894, 1895, and 1901. The last of these papers is based largely on the report of a committee of the British Association for the Advancement of Science, presented at its Bradford meeting, in 1900, by Prof. Coleman as secretary of the committee, with a separate report on the known Pleistocene flora of Canada by Prof. D. P. Penhallow. The mollusca were determined by Dr. William H. Dall, and the insects by Mr. Samuel H. Scudder. The great numbers of species reported far surpass any other locality of fossiliferous interglacial beds in America.

Coleman writes in his latest paper as follows:

WARM CLIMATE BEDS OF THE DON VALLEY.

> The earliest beds of the Toronto formation were deposited on the eroded surface of the Iowan till or on the shales which had been laid bare beneath it by river action; and they were formed probably in the shallow waters of a lake, though some features suggest the action of currents. At the bend of the Don, coarse, little rounded shingle of the harder layers of the underlying Hudson River rocks makes the lowest bed visible above the present river, and suggests the action of a current rather than of waves. Thick sheets of vegetable matter, greatly decayed twigs, leaves, reeds, etc., with trunks and branches of trees, are interbedded with the shingle, however, showing that the current could not have been swift. Possibly these beds were formed just at the mouth of a small river like the present Don, where

it entered a lake standing twenty or thirty feet higher than Ontario. If this is correct, there had already been a damming back of the interglacial waters to a higher level than has been reached yet in Postglacial times. This damming could not have been by ice, for the climate was at least as mild as at present, since the tree trunks referred to include wood of the red cedar, an elm, the pawpaw, and three species of oak; and among the shellfish there are two not reported from Canadian waters at the present day, though found in the Mississippi, Quadrula (Unio) pyramidata and Anodonta grandis. * * *

SECTION AT TAYLOR'S BRICKYARD.

		FEET.
8.	Yellow or brown sand with some reddish clay (no fossils)	3-60½
7.	Blue peaty clay with some gray sand (Unios, wood, caribou horn)..	4½-57½
6.	Yellow to brown sand with thin layers of purplish clay (shells)..	14-53
5.	Fine gray and yellow sand (Unios and other shells)......	3-39
4.	Blue stratified clay and sand (Unios. with other shells, and logs of wood), above 2½ feet of boulder clay resting on Hudson River shale................................	2-36

SECTION AT BEND OF DON.

3.	Brown clay with sandy layers (Unios Campeloma, etc)..	5-34
2.	Blue clay with sandy layers (Unios, Anodons, wood):..‥	6-29
1.	Coarse shingle with clay and peaty layers (shells and logs)	4-23
	River Don above lake Ontario..........................	19-19

From the combined section given above it will be seen that the warm climate beds of the Don, commencing 19 feet above lake Ontario, have a total thickness of 41½ feet. * * * The lowest point at which the Unio clays and sands have been found is 41 feet below lake Ontario at the foot of Scarboro' Hights, giving a vertical range of more than 100 feet for the whole series of warm climate beds. * * *

In all there are thirty-nine undoubted species of mollusks, and three more probably, included in the fauna. Of these eight or ten have not been reported from lake Ontario, but occur farther south. [See Prof. Coleman's paper for lists of the species of the fauna and flora.]

Professor Penhallow * * * states that "within this area no less than thirty-eight species [of plants, mostly trees] have been recovered, and they point conclusively to the existence of climatic conditions differing materially from those which now prevail, and of a character more nearly allied to those of the middle United States of today." "Only one species appears to have disappeared in Pleistocene time. Acer pleistocenicum, which was abundant in the region of the Don, bears no well defined resemblance to existing species."

The plant remains consist chiefly of wood and leaves, the former usually much flattened from the pressure of the later ice-sheet, but otherwise often well preserved, the red cedar, for instance, showing its color and being still quite tough, although some of the wood, probably decayed before being water-logged and included in the clay, is in a worse condition. Parts of the wood are almost of the nature of brown coal, breaking across easily and showing a coaly luster on the broken surfaces. It may be worthy of mention that some large bits of porous charcoal, as if from the burning of a log, were found cemented with limonite in the sand (No. 6) just under the blue clay. The leaves are preserved generally in the thinner body of clay, and are rarely obtained whole. * * *

THE SCARBORO' OR COOL CLIMATE BEDS.

After the close of the Don period, the interglacial lake deepened greatly, finally standing more than 150 feet above lake Ontario, and a great series of clays and sands were deposited by the Laurentian river in the form of delta materials in the wide and deep bay at this time extending still farther to the north than before. As seen at Taylor's brickyard, the clay beds, gray and finely laminated, with a few thin peaty layers, rest conformably on the brown sand at the top of the Don beds. The thickness, however, is not great, on account of later interglacial erosion, at the south end of the clay pit only 7½ feet, 70 yards north, 13 feet, and a quarter of a mile to the northeast, 30 feet. These clays are magnificently shown at Scarboro' Heights, where they were carefully studied by Dr. Hinde. They commence, as shown in a well sunk on the shore beneath the cliff, about five feet below lake Ontario, and rise eighty-five or ninety feet above it. The upper surface mingles somewhat with the overlying sand and varies in hight to some extent. The clay is gray, very firm and resistant, almost as much so as the Hudson River shale of the region, and is generally finely laminated, though there are beds from two to four or five feet thick, showing little or no lamination. Besides the fine lamination there are often thin layers of grayish silt with peaty material at distances of one or two inches apart, perhaps representing flood seasons of an annual character. These silty layers cannot often be traced for more than a few feet horizontally, and may run up or down into a bed showing no lamination in a way suggesting cross bedding. Another very characteristic feature is the presence of half inch sheets of greenish impure siderite every two or three feet, though these are not found everywhere.

The silty layers with peaty substances when washed to remove clay and then dried and looked over with a lens show great uniformity in all parts of the region. Scales of mica are always numerous, as well as mosses, spruce leaves, certain round black seeds, and chitinous portions of beetles. So constant is this assemblage that these clays are easily recognized by it when found in new localities, the clay ironstone sheets affording an additional earmark. Finally these are the only clays in the region which burn to a dark red brick. As their materials must have been derived by the Laurentian river and its tributaries from the calcareous boulder clay of the valley to the north, much of the lime must have gone into solution by artificial weathering before reaching the river or have been dissolved during the time of transport, thus allowing the red color due to iron to appear on burning. * * *

Dr. S. H. Scudder, who determined the beetles, thinks that all but two of the 72 [species listed in Coleman's paper] are extinct. * * * The number of species of beetles could no doubt be extended if the work of determining them were not so very laborious. In addition to the beetles, cyprids occur, and rarely also fragments of Sphæriums.

The plants include several trees, Prof. Penhallow having found Larix americana, Picea alba, and another species of Picea, in materials from Price's and Simpson's brickyards; while Dr. Macoun found leaves apparently of willow and alder in peaty material from Scarboro', as well as two shrubs, Oxycoccus palustric and Vaccinium uliginosum, and some smaller plants, such as Equisetum, Carex aquatilis, and C. utriculata. Dr. Hinde reports five species of mosses. * * *

Dr. Scudder judges from the relationships of the beetles to modern forms that the climate had "a boreal aspect, though by no means so decidedly boreal as one would anticipate under the circumstances." The same conclusion is reached by Dr. Macoun and by Prof. Penhallow from the plant remains. * * *

The peaty clay occupies the western part of the great bay into which the Laurentian river emptied when the interglacial lake was at its greatest hight. * * * the whole extent of the beds [is probably] 25 miles from east to west. The last exposure known towards the north is 6½ miles inland from lake Ontario, and no doubt if the cuttings of the Don were deep enough it would be found considerably farther north. The greatest thickness of the clay at Scarboro' is about 94 feet, 5 below the lake and 89 above: but the upper limit is rather hard to fix, since it becomes interbedded with sand. * * *

INTERGLACIAL SANDS.

Above the peaty clay at Scarboro' there are stratified sands with a thickness of 55 or 60 feet where best developed near the central part of the Hights, following the lower beds conformably and apparently laid down in shallower water but under similar climatic conditions. The lower 4 or 5 feet have clayey layers, but above this the sand is quite coarse, though free from pebbles, and shows cross bedding in some layers. In the sand are found all the usual minerals of Archean rocks, and a few bands of garnet and magnetite occur, evidently arranged under wave action, as on the present beach at the foot of the cliff. Just over the peaty clay there is sometimes an accumulation of coarse woody material, flattened twigs, bits of bark, etc., with quite large branches of Larix americana and Abies balsamea: and similar layers, but in less quantity, occur at a few points twenty or thirty feet higher up in the cross bedded sand. Near the top of the sand numerous nut-like concretions of brown iron ore are found, and occasionally also a few shells, such as Sphaerium rhomboideum, S. fabale, Limnaea sp., Planorbis sp., and Valvata tricarinata, but Unios have not been obtained from them. The stratified sands were apparently laid down like the clays, from materials brought from the north by the Laurentian river, but in the shallower water where wave action was effective, forming wide sand flats and largely filling the western side of the bay previously described.

A series of interglacial sands and gravels occurs in western Toronto, and is well exposed in large pits near Christie and Shaw streets; but its exact relation to the Scarboro' deposits is not certain. Where the two series meet near the corner of Dupont and Bathurst streets there are two or three beds of clay with peaty layers interstratified with sand, suggesting that the sand and gravel are of the same age as the Scarboro' clay.

The sand and gravel beds have a thickness of at least 78 feet, and rise 130 or 140 feet above lake Ontario, but their extent is unknown, as they are in general buried under boulder clay. It is certain that these beds were formed under different conditions from those either of the Don or Scarboro'. They are of coarser and more variable materials, often showing very marked cross bedding, probably produced by currents rather than waves, and sometimes apparent unconformities such as are made by a stream changing its bed. We may suppose that an interglacial Humber river coming in from the west or northwest, brought down sand and gravel at the edge of the great bay, mingling them at some points with the clayey delta materials of the Laurentian river.

This brings to a close the series of deposits forming the Toronto formation. In all there are four varieties, the sands and clays of the Don, with their warm climate trees and Mississippi Unios; the peaty clays of Scarboro', with their seventy distinct beetles and their small flora, suggesting a cool but not arctic climate; the stratified sands overlying them, probably forming a continuation of the cool climate period; and the western sands and gravels, with elephants, bisons, and some shell-fish, affording little evidence as to climate. The maximum thickness observed in each set of deposits is as follows:

3. Scarboro' sands	60 feet.	4. Western sands and gravels	78 feet.
2. Scarboro' peaty clays	94 feet.		
1. Don beds	41½ feet.		
	195½ feet.		

These Toronto and Scarboro' interglacial deposits, after being spread as a vast composite delta plain, with gentle lakeward slope, were deeply channeled by several streams before the ensuing glaciation covered the whole with alternating sheets of till and modified drift. On the present shore these valleys, partially filled by the later drift, descend below the level of lake Ontario, showing that after the delta accumulation this part of the lake held for some time a lower level than now.

Subsequently a snowy climate again caused an ice-sheet to overspread this area, with repeated oscillations of its border. The oncoming and wavering of this glaciation, shown by its drift series, have also been described by Coleman as follows:

> The halt at the Scarboro' delta was long. and must have included at least three great oscillations of retreat and advance, to account for the complex of tills separated by stratified materials now crowning the hights. The first sheet of till is shown for about nine miles continuously at Scarboro' with the shape of a slightly bent bow, touching the lake at each end, and with a sharp downward dip at the Dutch church. The latter is however, less symmetrically placed than in a bow, being only three miles from the west end and six from the east. The hollow of the Dutch church valley was filled with till containing comparatively few stones to a level 50 or 60 feet above the present lake, then merging into gray stratified clay which rises to a hight of 165 feet, where it is covered with a few feet of much later Iroquois beach gravel. Very similar clays rising to the same hight, or a little higher, are found at brickyards to the north of Toronto. They burn to a gray brick, and so are easily distinguished from the peaty clay which makes red brick.
>
> The highest part of the Scarboro' escarpment, about a mile east of the Dutch church, gives the best section of these complex glacial deposits. At the point where the old Iroquois beach is cut off for a distance by the present lake cliff, there is a face of 270 feet displaying three layers of boulder clay separated by stratified sand, the whole overlying the stratified fossiliferous sands of the Toronto formation. A few hundred yards to the east of this the escarpment reaches its highest level, 354 feet above the lake, but the lower part is not so well shown. The upper portion is, however, more complete, since overlying the third till sheet one finds laminated grayish blue or purplish clay followed by evenly bedded fine sand, on which rests a fourth boulder clay. Putting the two sections together, we have the following complete section:
>
> | | FEET. | |
> |---|---|---|
> | Boulder clay, No 4 | 48-354 | 203 feet. Glacial complex. |
> | Stratified sand overlying stratified clay | 36-306 | |
> | Boulder clay, No. 3. | 32-270 | |
> | Silty sand, the upper layers crumpled | 25-238 | |
> | Boulder clay, No. 2 | 9-213 | |
> | Cross bedded sand | 29-204 | |
> | Boulder clay, No. 1 | 24-175 | |
> | Fossiliferous sand | 59-151 | 151 feet. Toronto formation. |
> | Peaty clay | 92- 92 | |
> | Lake Ontario | 0 | |
>
> No fossils have been found in the sands or clays of the glacial complex at Scarboro', but a few have been picked up in stratified sand lying between two beds of boulder clay at the Metropolitan power

house, a mile or two north of Toronto. Amnicola limosa, a Succinea, and fragments of another species. These occur at 220 feet above the lake, but the sand containing them runs up to 247 feet and may correspond to the silty sand between till No. 2 and till No. 3 at Scarboro'.

One of the recessions of the ice, perhaps the one just mentioned, appears to have been very extensive, for two thick beds of boulder clay are found to be separated by stratified materials at numerous points on the lake shore as far east as Newtonville, fifty miles from Toronto. The same relationship is found near the head-waters of the Don, about eight miles north of the city, and also in ravines to the east, but has not been observed to the immediate west; though the stratified clays lying between two layers of till at Dundas and at several points near Niagara Falls may correspond to the same interglacial stage. In that case the ice must have withdrawn eighty miles in a northeasterly direction before advancing again.

* * * The highest boulder clay has not yet been traced with certainty west or south of the Toronto region, however, since the four sheets of boulder clay are very much alike and cannot be discriminated when found alone; and there is a possibility that it ends here, and that the water then filling the Ontario basin was continuous with that of some of the successors of lake Warren.

In several earlier papers, treating of the causes of the Ice age, I have attributed the snow and ice accumulation to great uplifts of the land areas which were glaciated, giving to them a cool and snowy climate throughout the year. From the depths to which preglacial land valleys are now submerged beneath the sea level on the coasts of North America and Europe, it is known that the elevation of the glaciated portions of these continents was 3,000 to 5,000 feet higher than now.

After a very long duration of the somewhat fluctuating ice-sheet on each of these continents, the glaciated areas sank to their present hight or mostly somewhat lower, so that when the ice melted away the sea covered coastal portions of the drift-bearing countries. The great change of climate resulting along the borders of the ice-sheet on account of the land depression caused rapid melting there, and this advanced inland until all the ice disappeared. The depression from the former high altitude, as was remarked by Dana, would transfer the southern part of the ice-sheet from a climate like that of Greenland to the temperate climate of southern Canada and the northern United States. Marginal melting then gradually pushed back the boundary of the ice and thus gave to its front an increased steepness of slope, whereby any slight halt or readvance due to a series of years of unusual cold and snow-fall became recorded in a marginal moraine.

The predominantly wasting ice border rose probably to an altitude of 5,000 feet within a hundred miles from its edge while being dissolved by the warm Champlain climate with somewhat lower altitude of the land than now. If the retreat of the ice-sheet from the northern United States and Canada occupied, as I think, some three to five thousand years, disappearing earliest from the upper Missouri and Mississippi basins, and latest from New England, the province of Quebec, and Labrador, the extension of a warm temperate flora and fauna could well keep pace with the glacial recession, so that, as on the waning Malaspina ice-sheet, a flora like that of the same latitude today, and concomitant temperate molluscan and insect life, may well have thrived up to the very boundary of the ice, or perhaps in the case of the plants and insects even extending, as in Alaska, upon the drift-covered ice-border.

Darwin noted, in his narrative of the voyage of the *Beagle*, that glaciers in the fjords of southern Chile reach down to the sea level within nine degrees of latitude from where palms flourish. Professor W. O. Crosby tells me of his observations of fine orchards of cherries and other fruits cultivated close to the limits of the large local fields of ice and névé in Norway, one of which has an area of about five hundred square miles. In the Alps the glaciers end only a few hundred feet from productive fields and gardens of flowers. Still more like the condition of North America and Europe during the recession of their Pleistocene ice-sheets is the vast fertile plain of India, enjoying a tropical climate, while within a short distance along its northern side, and farther west and east for an extent of 1,500 miles, runs the almost impassable Himalayan range with valleys bearing glaciers and summits crowned with perpetual snow.

The proximity of the very cold Himalayas does not bring frosts to the neighboring tropical plain. In like manner the ice-sheet still lingering on northern Ontario, New York, and New England, probably did not cause a very frigid climate to prevail in the winters, nor nights of frost in the summers, on the windward low region of the Laurentian lakes whence the ice had recently retreated.

The thick stratified clay and sand beds forming the lower half of the Scarboro' section were evidently amassed as a delta or broad alluvial slope, perhaps wholly above the water level in the Ontario basin. So large a supply of sediments seems referable to their derivation partly from englacial drift exposed by ablation on the margin of ice-fields within the drainage area of the delta-forming streams. In this tract of confluence between the great eastern and central lobes of the Laurentide ice-sheet, represented by the angle of the drift boundary at Salamanca in southwestern New York, there undoubtedly was brought an exceptional volume of the englacial drift by the confluent glacial currents. Much of these clays and sands may therefore have come from englacial and finally superglacial drift of the neighboring ice-sheet on the northeast, being brought by streams from its melting; while the driftwood and leaves of trees, and mosses of peat bogs, growing within a few miles westward, were contributed to the same deltas by streams flowing from a wooded land area bordering the ice, such as Russell found adjoining the Malaspina ice-sheet in Alaska and even extending its forest growth several miles upon the drift-covered margin of the departing ice.

When the delta, with its fanlike lakeward slope, had attained the maximum depth of nearly 200 feet in the Scarboro' section, lying partly beneath the present lake level, it was deeply channeled by the principal streams, which no longer carried so abundant silt for deposition on that outer part of the delta area.

Later a moderate readvance of the ice-sheet seems to have brought much englacial till, boulder clay, over this district, to be deposited when that thin ice margin melted away; and upon this till the streams flowing from the ice front spread a thickness of twenty-nine feet of cross bedded sand. With the oscillations of small extent and short duration which the ice border often made during its accumulation of marginal moraines, the same alternations of boulder clay and sand were repeated until four distinct deposits of till and three of intervening sand beds, marking four ice advances and recessions, crowned the ridge of Scarboro' Heights, attaining together the thickness of 203 feet.

Several species of the molluscan fauna which earliest came into the region of Toronto, following the retreat of the ice, were later unable to survive, when brought more fully into competition with the eastern fauna of the coastal region; but they are still living farther south and west, within the Mississippi drainage area. It is also especially noteworthy that the very rapid evolution now in progress producing the exceedingly abundant species of insects is shown by the changes, or less probably the extinction, of nearly all the species of beetles found in the Scarboro' delta deposits.

If all this history was subsequent to the beginning of the erosion of the Niagara river gorge, and previous to the rise of this western part of the glacial lake Iroquois, occasioned by the uplifting of the country including its outlet at the east, to form the upper Iroquois beach of Toronto and its vicinity, which I think probable, only a few hundred years, or perhaps a thousand years, more or less, must have sufficed for the deposition of the Toronto and Scarboro' interglacial and glacial series. This conclusion seems well consistent with the apparent evidences of seasonal changes, as if marking years, which Coleman mentions as frequent in the Scarboro' peaty clays.

EDITORIAL COMMENT.

ANNOUNCEMENT OF THE THEORY OF EVOLUTION.

There is no more notable event in the history of science than the joint presentation before the Linnean Society in 1858 of papers by Charles Darwin and Alfred Wallace announcing the theory of evolution by natural selection. Darwin, as is generally known, was most careful in his methods of work. His theory in regard to the transmutation of species by natural selection was slowly thought out from the time of the voyage of the *Beagle,* and was put in writing in 1844. This manuscript was shortly afterwards shown to Sir Joseph Hooker and others; but Darwin continued to collect facts and to postpone publication. In 1858 Wallace sent him from the East Indies a letter not specifically intended for publicaiton, announcing the same theory of natural selection. Darwin was at first inclined to publish Wallace's paper by itself, but was persuaded by Sir Charles Lyall and Sir Joseph Hooker to have read before the Linnean Society at the same time as Wallace's paper an extract from his unpublished manuscript of 1844 and a letter addressed to Asa Gray. The papers by Darwin and Wallace and a statement by Lyell and Hooker were read before the Linnean Society in 1858 and subsequently published in the Journal of the Society. These documents, to which attention is called by their reproduction in the November number of *The Popular Science Monthly*, are of very great interest both in themselves and in comparison with the full presentation of the theory of evolution by natural selection published later by Darwin and Wallace.

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THE AMERICAN PHILOSOPHICAL SOCIETY.

The American Philosophical Society, Philadelphia, founded in 1743 through the instigation of Benjamin Franklin, is the oldest scientific society in America, and ranks among the oldest in the world. Its publications are found in the principal libraries of this country and of Europe. Its membership embraces many of the most prominent scientists of America, and represents the extended national basis on which the society is founded. Arrangements are being made by a committee of the society to enlarge the facilities "for promoting useful knowledge" to which the organization is devoted by the terms of its first circular issued by Franklin, and for widening the plan of publication. It is proposed to hold, in addition to the usual semi-monthly, an annual general meeting designed to attract members of the society from all parts of the country. Papers read at this annual meeting will be of a more general scientific character, and their prompt publication will enable the society to be the avenue of announcement of important results of more extended research. The first annual meeting is to be held Easter week, 1902. This plan, if its results are commensurate with the expectations of the society [illegible] only give an auspicious opening for the twentieth [illegible] will serve to promote the society and the interests for the advancement of which it was established. The career [illegible] society has been an honor to America. The next [illegible] promises to rank well with the last. [illegible]

REVIEW OF RECENT GEOLOGICAL LITERATURE.

Geology of the Eastern Choctaw Coal Field; by [illegible] Taff and [illegible] Adams. (U. S. Geolog. Surv., [illegible]th Ann. Rept., Pt. [illegible] 1901.)

To those interested in the American Carboniferous [illegible] contribution to our knowledge of the Ouachita district [illegible] interest. The reason is the enormous thickness of the [illegible] section that is said to prevail in this district. The eastern [illegible] coal field is in the eastern part of Indian Territory [illegible] from the Arkansas river. It therefore lies [illegible] may be expected much critical evidence bearing upon the most [illegible] Carboniferous history on this continent.

[illegible] this country [illegible] more instructive [illegible] which the Choctaw field is situated. [illegible] the most notable features [illegible] isolated mountains. These however [illegible] between the mountains grade insensibly northward [illegible] the greater [illegible] Arkansas. The streams of the lowland are [illegible] and in general are sluggish [illegible] which are very little below the general [illegible] upland plain is also in evidence. [illegible] nearly level uplands [illegible] above [illegible] horizontal plane [illegible] the country [illegible] the Arkansas river drainage [illegible] elevations approximating the [illegible] of the Ouachita mountains [illegible]

The mountains of the Choctaw region are all of the same type and have similar detail of surface features. They are all of synclinal structure, and the same formations occur in all four of the mountains in this field and in nearly the same relative position. The sides of the mountains, knobs, peaks, or ridges have the bench and terrace type of sculpture.

The geological structure, stratigraphy and economic features are clearly described. Regarding the distribution of the coal seams of the district it is stated that "Seven workable beds of coal are known in the eastern Choctaw coal field. They occur in four different formations, from the top of the Hartshorne sandstone, which is the lowest coal-bearing rock known in Indian Territory, upward to the lower part of the Boggy shale. The thickness of the rock between the lowest and highest of these coals is estimated to be nearly 3,600 feet. Besides these coal beds, which are profitably worked, there are a number of others that are thin and have been located, chiefly by prospect drill, in various parts of the McAlester shale and Savanna sandstone.

"A knowledge of the geological structure of the rocks in which coal beds occur and of the combined effects of structure and erosion on the topography or surface configuration of the land is necessary to the most successful economic prospecting and exploitation of the coal. Except to test the thickness and quality of a particular coal bed, the drill need not be called into use in a coal field of this nature. All the known coal beds are associated with sandstone beds of considerable persistency, which make their presence and location known by more or less elevated hills and ridges. When the interval between such sandstone and coal beds is once established, the crop of the coal may be located as rapidly as the sandstone ridge or outcrop can be traversed. The dip of the sandstone may be determined at almost any point by measurements on its outcropping edges. The coal beds, on the contrary, usually lying in shale, have their edges worn down and concealed by soil and rock debris."

Good maps accompany the memoir. Also a few paragraphs on the composition and adaptability of the coals. C. R. K.

Geology and water resources of Nez Perce county, Idaho. I. C. RUSSELL. (U. S. Geol. Sur., Water supply papers, Nos. 53 and 54, 1901).

This document is more than a treatise on the water supply and irrigation of Nez Perce county, for it enters largely into the interesting geology of the region, and presents some very fine plates showing the cañons eroded by the streams.

Prof. Russell notes two sharply defined rock groups—a pre-Tertiary and a Tertiary. The former embraces a large variety of rocks of both igneous and sedimentary origin, and large areas of metamorphic rocks. These are disturbed by folding and otherwise and once formed a land surface that was deeply denuded before the younger group was spread upon it. The Tertiary group consists largely of igneous rock, either basalt or volcanic tuffs, but occasionally it has layers of clay, lignite, sand and gravel. It is nearly horizontal. The older group carries some gold and ores of other metals, but on decay forms a very poor soil. The younger is without native metals and ores but forms a deep dark soil of marvelous fertility. Possibilities of artesian water inhere only in the younger group. The age of the pre-Tertiary group is, in part at least, probably Mesozoic, this being indicated by fossils found in certain limestones. The younger group is Tertiary, as shown by fossils found associated with some of the sedimentary beds lying between basalt sheets.

Prof. Russell judges that in southern and central Idaho, in the Glacial epoch, there were only isolated Alpine glaciers, and no general or continental ice-sheet. These Alpine glaciers produced one of the most marked of the drift phenomena of Idaho, viz. the overwash gravels. The great lava plain is called the "Columbia River lava.' Through it protrude many isolated peaks or islands of the pre-Tertiary rocks. These are dominated, generically, *steptoes*, a name derived from Steptoe butte, near Garfield, in Washington. The largest of these known is Eagle Creek range, or Powder River mountains, in Oregon, which, as stated by Lindgren, consists of bare ragged peaks that rise several thousand feet above the basaltic plateau, surrounding them on all sides. This steptoe has a diameter of twenty-four miles.

The Columbia River lava is the most remarkable feature of the geology of the region. It is almost entirely within the drainage area of the Columbia river, covering nearly the whole of Washington and Oregon east of the crest of the Cascade mountains, and extends into Idaho to the Cœur d'Alene and Bitterroot mountains. Its whole area is estimated at 200,000 or 250,000 square miles, its greatest known thickness being 4,000 feet. Following is Prof. Russell's terse description:

"The lava was outpoured at successive intervals, embracing a long period of time, as is shown by the occurrence, at several horizons, of layers of sedimentary material, principally clays and sands, between the lava sheets. In places also the lava sheets are separated by layers of volcanic dust containing the silicified trunks of trees which grew on a soil formed by the decay of the underlying layer, thus showing that the intervals between the flows were in some cases a century or more in duration. The lava came through fissures in the earth's crust--in what are known as fissure eruptions—and spread widely over the land, from which it is evident that each sheet was spread out horizontally. The movements that have occurred in the layers since they cooled and hardened, and which have caused them to be deformed from their original horizontal position, can be studied in the same way as the structure of sedimentary beds. Although the lava sheets are still essentially horizontal over broad areas, they frequently have gentle dips, and in certain regions are tilted and even sharply folded and faulted. On the eastern slope of the Cascade mountains the lava sheets occur with a dip to the eastward, for long distances, of three or four degrees, showing that a large part of that range has been elevated to a hight of at least 6,000 feet since the lava was poured out. Similar but less extensive deformations have also occurred on the eastern side of the lava-covered country, as will be described further on. Between these bordering areas is the region of the great plains of the Columbia, and southward from it, in Oregon; the lava sheets have, in general, been but little disturbed from their original horizontal position, although a subsidence of three or four thousand feet has probably taken place. Extensive movements in the earth's crust occurred also at certain periods during the time the lava sheets were being formed, as is shown near Clealum, Washington, on the eastern slope of the Cascades, where the upturned and eroded lower portion of the formation is overlain unconformably by later sheets. How widely extended this unconformity may be remains to be determined."

As determined by Mr. Diller this lava consists of plagioclase, augite, olivine and magnetite, with considerable globulitic base.

N. H. W.

Geological Survey of Canada. Annual Report. New Series, Volume XI, 1898. GEORGE M. DAWSON, Director. Parts A, D, F, G, J, L, M, R, and S; together 856 pages, plus 30 pages in Table of Contents and Index; with numerous plates, and four folded maps. Price, 80 cents. Ottawa, 1901.

The summary report of the Director fills 208 pages, narrating the progress of the several departments of the Survey during the year 1898, with outlines of work by field parties, and brief statements of some of their observations and discoveries. Four maps on the scale of eight miles to an inch were completed and printed, comprising an aggregate of about 125,000 square miles. Ten maps on larger scales were also published, seven of these being maps of gold mining districts. The number of visitors to the Museum during the year was 33,183, being more than in any previous year. The entire staff employed in the Survey numbered forty-eight; and the legislative appropriations for it amounted to $107,600.

The second part (D) of this volume is a report, in 44 pages, by Mr. James McEvoy, on the geology and resources of the country traversed by the Yellow Head Pass route from Edmonton to Tête Jaune Cache, on the Fraser river, comprising portions of Alberta and British Columbia. The rock formations, beneath the drift, are of Tertiary, Cretaceous Devono-Carboniferous, Cambrian, and Archean age.

Mr. A. B. Dowling describes, in the third report (F), of 100 pages, the geology of the west shore and islands of lake Winnipeg. The area of this lake is stated as 9,414 square miles, being 2,150 more than lake Ontario; but it is comparatively shallow, as its maximum recorded sounding is 96 ft. The rock series belongs to the Cambro-Silurian system. It consists of the Winnipeg sandstone and shales, about 100 feet thick, probably of Black River age; the Trenton formations, a lower mottled limestone, about 70 feet thick; the Cat Head limestone, also about 70 feet, and an upper mottled limestone about 100 feet; and the Stony Mountain limestone and shales, probably of the Utica age, 110 feet. The boulder clay, or till, attains a maximum thickness of nearly 100 feet; and on some of the islands and shores it forms low drumlin ridges, running southward, parallel with the course in which the ice-sheet flowed.

The next part (G), in 98 pages, is a report on the east shore of this lake Winnipeg, with adjacent districts of Manitoba and Kewatin compiled by Mr. Dowling from notes and surveys by Mr. J. Burr Tyrrel. This side is in marked contrast to the west, as the rocks are wholly Archean, the preponderance of gneisses and granites of the Laurentian being the chief feature. There are also large areas of stratified clay and silt, deposited in the glacial lake Agassiz, having a rich soil, covered with poplar and spruce forests.

Dr. R. W. Ells reports, in 70 pages (J), on the geology of the Three Rivers map sheet, which is the northwestern sheet of the "Eastern Townships" of Quebec. It comprises nearly 7,000 square miles, mostly yet unsettled, with no means of communication excepting by canoe and portage routes. The rock formation range from the Silurian to the Archean. Pleistocene marine shore lines are stated by Chalmers to occur up to hights of about 500 to 900 feet, showing differential postglacial elevation of the land, the maximum slopes of the highest beaches being about two feet to the mile, rising from east to west.

An exploration of a part of the south shore of Hudson strait and of Ungava bay is reported by Mr. A. P. Low, in 47 pages (L); and a similar report on the northern side of Hudson strait is supplied in Part M, 38 pages, by Dr. Robert Bell. These reports are accompanied by a map, on the scale of 25miles to an inch, colored to show the rock formations along these coasts.

Dr. G. C. Hoffmann, chemist and mineralogist to the Survey, reports his work for the year in Part R, 55 pages; and the Scection of Mineral Statistics and Mines in charge of Mr. E. D. Ingall, is reported in Part S, 196 pages. The total value of metallic products was $21,705,854, being eight times greater than in 1888, ten years earlier; and of non-metallic products, $38,661,000, being thrice greater than ten years before.

W. U.

Contributions to Mineralogy and Petrography, Sheffield Scientific School. Edited by S. L. Penfield and L. V. Pirsson. Octavo, pp. 482. New York. Charles Scribner's Sons. 1901.

This volume is composed, essentially of reprints of papers by Brush, the two Danas, Penfield and Pirsson, professors at Yale college, and by numerous young men who have been associates at that institution, viz. Hawes, Wells, Allen, Comstock, Harper, Meyer, Farrington, Pratt, Howe, Minor, Foote, Warren, Ford, Weed and Gregory. It also contains a sketch of the progressive development of mineralogy and petrography at Yale, complete bibliographies of the papers emanating from Yale, and occasional comments and footnotes by the editors intended to elucidate the corrections and discrepancies which lapse of time has rendered apparent. The work issues and is edited from New Haven, is published by firms in New York and London, and is printed at Cambridge, Mass., a fact that indicates not only the cosmopolitan spirit in which it is published, but the cordiality existing between the old university towns of New England.

Probably no greater service could be rendered to American mineralogy and petrography than that which is served by this publication. By all odds Yale has been the American head center of these sciences, and this volume will serve to perpetuate that leadership. These papers are gathered mainly from the American Journal of Science, the earliest being that of Brush, published in 1849, but some are from other sources. The volume is one of a series that have been prepared by the professors to commemorate the bicentennial of Yale university, dedicated to "The Graduates of the University."

N. H. W.

Dragons of the Air. H. G. SEELEY. Methuen & Co., London, and D. Appleton and Company, New York, 1901. 12 mo. pp. 240, with eighty illustrations. Price $1.20.

This little work, which is small only in respect of material bulk, treats of one of the curious traits, one might almost say freaks, of the animal kingdom, viz. that of extinct flying reptiles. It has several plates showing the grotesque forms of the ornithosaurs, both in flying action and in repose on the earth, or walking. There is an opening chapter which is both mythological and anatomical, treating of all animals that fly or that have been believed to fly, fishes, frogs, lizards, birds, and mammals, including man. The volume is historico-scientifico-popular, very interesting and instructive, and should be in the library of every teaching geologist. N. H. W.

Preliminary report on the Copper-bearing rocks of Douglas county, Wisconsin, containing a preliminary report on the copper-bearing rocks of parts of Washburn and Bayfield counties. U. S. GRANT. (Wisconsin Geological Survey, Bulletin No. 6. second edition. 1901.)

Dr. Grant has given two vacation seasons to the field work on which this report is based. He has described in much more detail the same structure and field facts, and reaches, in the main, the same results as were announced in the Wisconsin reports, published in the seventies. In two important respects, however, he differs from those reports, viz. (1) He is not so sanguine of the existence of copper of economic value in northern Wisconsin as was Irving, and (2) he describes as a fault plane the breccia and the attendant features that mark the contact of the lake Superior sandstone on the trap all along the north side of the Douglas range, making it the probable western duplication or extension of the fault plane seen along the south side of Keweenaw point in Michigan.

This fault was formed after the deposition of the lake Superior standstone and the effect on the traps was extensive and remarkable. They are brecciated and reduced to extreme fineness sometimes for a distance of 400 feet from the fault plane but the sandstone, which lies on the north side and which has suffered a great down-throw, is rather thrown into a series of folds, or is broken into large faulted blocks, bending upward, even at sixty degrees from the horizon, at the fault plane.

It might have been well had Dr. Grant given some of the evidence of the long erosion interval which he alludes to as one of the steps in the geological history of Douglas county, said to have occurred between the sedimentary beds of the upper Keweenawan and the lake Superior sandstone. This is a mooted question. Evidently no proof of such erosion interval occurs within the field reported on, else it would have been mentioned. This erosion interval, however, was one of the tenets of the older Wisconsin survey and it seems to have been adopted by Dr. Grant without question. In a preliminary and subordinate report, however, devoted largely to economic facts, and to the description of the field geology, it would have been impossible to have gone into a theoretical question of that nature. In the writer's opinion there was no such erosion interval, but instead there was a progressive subsidence in the lake Superior region, followed later by flexure, faulting, and elevation above the sea. N. H. W.

An investigation of the buried valley of Wyoming. WILLIAM GRIFFITH. (Read before the Wyoming Historical and Geological Society. Jan. 11, 1901. Wilkesbarre, Pa.)

This old valley has long been known. It has been he cause of difficulty and some fatalities in the mining of the coal at Wilkesbarre. It is filled with gravel and sand, and other coarser drift, to the depth of 200 or 300 feet. If this filling could be removed there would be seen a lake eighteen miles long and a mile in width through which the Susquehanna river would flow. This river now flows along the surface of the gravel bed, but slightly impinging upon the rock rim. It is evident that this gravel is permeated by water for sometimes in mining operations both gravel and water rush into the mines that pass into the limits of the gorge. This gorge is an interesting example of the condition of the surface of the country previous to the drift age.

N. H. W.

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CORRESPONDENCE.

HEAVY RAINS AND POSSIBLE VOLCANIC ACTION IN NICARAGUA.—Rain has fallen in western Nicaragua for one to three hours each day, during the past eighty days; most frequently they have been torrental rains, flooding the streets in the cities of Granada and Managua eight to ten inches deep and rushing in rapid currents into the lakes Nicaragua and Managua.

The result is that the water in these lakes is now for this season of the year several feet higher than remembered by reliable citizens to have been since the high water in 1859-61.

Because of the unusually large rainfall thus far, this year, it is quite probable that next December and January [usual high-water months annually in the lakes above named] the water in lakes Nicaragua and Managua, will be more than two feet higher than the remembered by reliable natives, high-water years 1859-61, when they were about ten feet higher [so reliable people have declared to me] than when measured by the engineer corps of the Isthmean Canal Commission 1898-99-1900.

There appears to be a periodic time of about forty years of unusually high water—far above the usual hight. I am endeavoring to ascertain if there are not records, in the archives of the old Roman Catholic churches, some of them established in Nicaragua before A. D. 1600, of unusually high-water in these lakes—but it will probably take months of search among the confused mass of papers in each church before ascertaining whether such records exist.

What effect the pressure of this unknown stage of water will have in, say next October, November and December, on the semi-slumbering to apparently nearly extinict volcanoes in and near them, is looked forward to by me with much interest, because, from more than fifteen years of observations and studies of volcanic masses in the tropical Americas, I have formed the opinion that the varying pressure of water in and above the numerous fissures is most frequently the cause of volcanic activity. The fissures referred to are observable for hundreds of feet from the base of the volcano when the water surrounding it, or adjacent to it, is at a low stage, or traceable for miles in the earth near its surface when the volcano is not surrounded by, nor adjacent to, a large volume of water. These fissures are the escape, or safety valves, of apparently slumbering volcanoes, permitting high tension gases to escape as they near an exploding condition, except when the pressure of water in the lakes and bays surrounding or in part surrounding the volcanic mass becomes so great as to repress them. These gases are under pressure from the superheated magma formed miles down beneath the earth's surface. J. CRAWFORD.

Managua, Nicaragua, August 31st, 1901.

Second edition of the Geological map of West Virginia.—The new geological map of West Virginia first published under date of

January 10th, 1899, by the West Virginia Geological Survey, has recently been revised, new features added and republished under date of August 1st, 1901.

The map shows in separate colors the three great coal formations of West Virginia, viz.: the New River of Pocahontas, the lowest, the Allegheny-Kanawha series in the middle, and the Monongahela or Pittsburg (Connellsville) at the top. Two features not shown on the original map have been added in this edition, viz.: the prominent anticlinal lines, and the locations and names of every coal mine in the state shipping coal by rail or river, up to July 15th, 1901, the approximate locations of the mines being indicated by numbered black dots, and the corresponding names and numbers printed on the margin of the map by counties.

The State Geological Commission has placed this map on sale at the office of the survey at the price of 50 cents per copy from which there is no discount.

The map shows the coal, oil and gas developments of the state at a glance, and should prove of much use to every one interested in these subjects, even though the topographic base of the map is unavoidably very inaccurate, and must remain so until the topographic map now being constructed by the coöperation of the State and United States Geological survey shall have been completed five to six years hence.

Those who desire it should fill out the accompanying blank and enclose it with 50 cents to the office of the West Virginia Geological Survey, Box 448, Morgantown, W. Va.

I. C. WHITE.
September 20th, 1901. State Geologist.

NEW YORK ACADEMY OF SCIENCES. The first meeting of the Section of Geology and Mineralogy of the New York Academy of Sciences was held on October 21. In calling the meeting to order the chairman spoke of the loss to the Academy and to science occasioned by the death of Dr. T. G. White, secretary of the Section, and of professor Joseph LeConte, corresponding member of the Academy. A committee consisting of professors J. J. Stevenson and J. F. Kemp, was appointed to draw up suitable minutes in reference to Dr. White and professor LeConte.

Dr. E. O. Hovey, of the American Museum of Natural History, was then elected secretary of the Section.

The following program was then offered:

A. W. Grabau spoke on *Recent Contributions to the Problem of Niagara.* He said that Davis has shown that the topography of the Niagara region conforms to the type generally found in ancient coastal plains, the original features of which have been more or less modified by subsequent warpings, and by glacial erosion and deposition.

The Niagara escarpment is the inface of the Niagara cuesta, traceable through the Indian peninsula and Grand Manitoulin island. The Ontario lowland is continued in the Georgian Bay lowland. A second cuesta—the Onondaga—has its inface slightly developed north of Buffalo, but becomes prominent in the Lake Huron valley, where its inner lowland forms the deeper part of the lake. The third cuesta and lowland (the Erie) occurs north of the second.

The Tertiary drainage is supposed to have been to the southwest instead of the northeast as Spencer holds. The principal streams of that time are supposed to have been, (1) the Saginaw—whose path is indicated in part by Saginaw bay and the deep channel between the Indian peninsula and Grand Manitoulin island, (2) the Dundas, breaching the Niagara cuesta at Hamilton, Ont., and crossing the Erie lowland near Fort Stanley, and (3) for a time, at least, the Genesee, though this may later have had a northward course. The subsequent streams tributary to these consequents, carved the various lowlands. St. David's channel is regarded as an obsequent stream, which was accidently discovered by the Niagara. The whirlpool gorge was probably, in part, the southward continuation of this stream, and not wholly postglacial.

Professor J. F. Kemp's first paper was on the *New Asbestos Region in Northern Vermont.* He said that asbestos has recently opened up on a commercial scale in the towns of Eden, Lamoille Co., and Lowell, Orleans Co., Vt. The towns are adjacent, although in different counties. The asbestos lies from fifteen to twenty-five miles north of Hyde Park, a station on the St. Johnsbury and Lake Champlain R. R. As is quite invariably the case, it occurs in serpentine, either in veins, or in matted aggregates along slickensided blocks. The serpentine where the best fibre is found lies on the south shoulder of Belvedere mountain, and forms an east and west belt. It is bounded on the north and west by hornblende-schist, which forms the summit of the mountain. The contact on the west is a visibly faulted one, and that on the north is probably also of the same sort, because the hornblende schist rises in a steep escarpment.

The serpentine seems to have been derived from enstatite, since unaltered nuclei of this mineral are found in it. The vein asbestos ranges from a fibre of microscopic length up to ¾ of an inch as thus far exposed. It is fine and silky and of excellent grade. It would, however, be classed as second grade according to the Canadian practice, which makes a first grade, of fibre above ¾ of an inch (about 2½ inches being the maximum), and a second grade of ⅜ in. to ¾ in. All below this and all fibre not vein fibre goes to the mill and is mechanically separated, as the third grade. In the Vermont localities the slip fibre is exposed on the property of the New England Co., and of its neighbor, the American Co. The vein fibre is limited so far as yet opened up to the property of Mr. M. E. Tucker and associates.

It is difficult with the data in hand, which were gathered under the direction of Dr. C. W. Hayes, of the U. S. Geological Survey, to trace the geological history of the serpentine, but it must have been originally either an igneous pyroxenyte, or a richly magnesian siliceous limestone. There are such slight traces of calcium-bearing minerals however that the former supposition has the greater weight. The hornblende-schist consists of common green hornblende and of an unusual amount of titanite, there being little else than these two present.

Professor Kemp also gave a paper on the *Physiography of Lake George*. The observations extending over several years have suggested the following conclusions. Lake George occupies a submerged valley very similar to many others in the Adirondacks, which are not submerged. The valley has been largely produced by faulting, and the fault-scarps still remain in precipitous cliffs, whose sharpness has not been much affected by the weathering and erosion. Before the Pleistocene, the valley was probably a low pass with both a north and a south discharge. The portion rich in islands near Pearl point, and the Hundred Island house, was probably the divide, and the islands represent the old hillocks near the top of the divide. At the south the water is backed up by sands and morainal matter in the valleys on each side of French mountain, viz. at the head of Kattskill bay, and at Caldwell. On the north they are held in by Champlain clays and syenitic gneiss at the Ticonderoga outlet, and probably by morainal material at the low pass just south of Rogers rock and leading out to the very depressed Trout brook valley, just west of Rogers rock and Cook mountains. Trout brook is now as much as a hundred feet lower than lake George at points south of the Ticonderoga barrier. The northern barrier is rock because the Ticonderoga river passes through a narrow and shallow channel in the exposed ledges a mile south of its actual first waterfall. There is a broad flat valley buried in clays, however, beneath which an old channel may lie submerged. At the same time, the marked depth of the Trout brook valley to the west makes this the natural outlet and there is reason to believe from the general topography that the discharge passed north into the Champlain valley near the south boundary of Crown Point. It is also not to be overlooked that a valley with much drift leads eastward to lake Champlain, from the head of Mason's bay.

A curious feature that is common to both shores of the lake north of Sabbath Day point (and perhaps also south of it), is the presence of pot holes of great perfection and as high at times as thirty feet above the present level of the lake. These are best developed on Indian Kettles point, about two miles north of Hague. They are doubtless excavated by lateral or subglacial streams when the ice filled the lake valley, because in no other conceivable way could flowing water be forced into such unnatural situations.

There is great need of a good hydrographic survey of the lake, and of detailed pilot charts, with soundings. They would be of great service, not alone to navigators, but to science as well. So far as could be learned from local fishermen, whose deep trolling for lake trout gives them familiarity with the bottom, there appear to be channels whose general trend is parallel with the long dimension ofthe lake, and which have precipitous sides, precisely like the valleys and gulches now visible. The lake is relatively shallow as compared with lake Champlain. In lake George, the greatest depth is believed to be near "Anthony's Nose," and to reach 190 feet. Elsewhere the deep parts are placed at about 100 feet more or less. All this, however, requires confirmation by soundings; and with regard to the physiography one cannot say to what extent the bottom of the valley has been filled by drift, but the islands to which physiographic importance has been given by the speaker are rock.

RICHARD E. DODGE,
Secretary pro tem.

PERSONAL AND SCIENTIFIC NEWS.

PROF. W. O. CROSBY of the Institute of Technology, Boston, spent the summer in Arizona in the examination of certain mines.

PROFESSOR J. B. HATCHER, in camp near Canyon City, Colorado, has discovered the remains of another fossil animal in the famous bone beds of that section.

PROFESSOR W. B. SCOTT, of Princeton University, is still in South America working on the Patagonian reports. When last heard from he was at Buenos Ayres, examining specimens in the Museum of that place.—*Science.*

GEORGE B. SIMPSON who has been connected with the New York state department of paleontology since 1868 and thousands of whose beautiful drawings of paleozoic fossils have been reproduced in the publications of that department, died Oct. 15, at Albany.

MOVEMENTS IN THE ROCKIES. "The mountains are constantly moving," was the remark of an officer of the Denver & Rio Grande Road recently in speaking of the great landslides in the canyon above Glenwood Springs, Colo. "We find from actual experience in maintaining tunnels, bridges and tracks in the mountains that the mountains are moving. It costs a railway passing through the mountains a great deal of money in the course of ten years to keep the tracks in lime, and maintenance of tunnels is even more expensive. Drive a stake on the side of a mountain, take the location with the greatest care, and return after a few months. The stake is not in the same location. The whole side of the mountain has moved. This experiment has often been tried and in all cases the result proves that the mountains are moving. The mountains are gradually seeking the level of the sea."

While we do not agree with the last assertion that "the mountains are seeking sea level," there appears no question but that local movements are in progress in the Rockies and the observation of the railroad surveyor is confirmed by those experienced in some of the mines. In quite a number of mines located on fissure veins or between highly tilted strata, or in the vicinity of great faults, movements have been for a long time observed, and sometimes of so pronounced a nature that timbers after a few years are found so out of place as to require a complete new timbering of portions of a mine, and these movements do not seem to be the result as in coal mines of a creeping from excavation of material, but actual slipping or faulting movements of the mountain itself along certain lines, especially old fault planes and veins, the latter generally occupying fissures along fault lines.

A notable instance is in the mines of Smuggler mountain, at Aspen, Colo., where in some of the deep workings, timbers two feet thick and eight to ten feet long placed across the stopes are snapped in two like reeds and their ends broomed up by the overwhelming pressure and slipping movements of the walls. The ore bodies lie between strata almost vertically uptilted against a granite mountain or wall, and abound in faults and slipping planes. These movements are not the result of excavation of the ore, but appear to come from a general movement of the hills slipping or faulting off from the granite wall.—*Mines and Minerals, of Scranton, Pa., for September, 1901.*

FIELD COLUMBIAN MUSEUM SIXTEENTH FREE LECTURE COURSE, Autumn, 1901. A course of nine lectures upon Science and Travel has been arranged by the Museum for Saturday afternoons in October and November at the usual hour, 3 o'clock. All of these lectures will be illustrated by stereopticon views. The lectures are given in the Museum Lecture Hall. Entrance doors will be closed at ten minutes past 3 o'clock. Admission free. Subjects, dates and lectures: Oct. 5, The Megalithic Monuments of Brittany, Dr. George A. Dorsey, Curator, Department of Anthropology, Field Columbian Museum; Oct. 12, Through the Arizona Cañon and Yosemite to the Glaciers of Alaska, Dr. Edward Burton McDowell, Chicago; Oct. 19, The Houses and Family Life of the Natives of Sarawak, Borneo, Dr. Alfred Cort Haddon, F. R. S., F. Z. S., University of Cambridge, England; Oct. 26, The Ceremonial and Secular Dances of the Papuans, Dr. Alfred Cort Haddon, F. R. S., F. Z. S., University of Cambridge, England; Nov. 2, Economic Geology, Particularly of Michigan, in its Relation to the Business World, Prof. Alfred C. Lane, State Geologist, Michigan; Nov. 9, Color in Nature, Prof. William H. Dudley, Platteville, Wisconsin; Nov. 16, Mexico, Dr. S. E. Meek, Assistant Curator, Department of Zoology, Field Columbian Museum; Nov. 23, Recent Dinosaur Discoveries, Mr. Elmer S. Riggs, Assistant Curator of Paleontology, Field Columbian Museum; Nov. 30, Crystals, Prof. O. C. Farrington, Department of Geology, Field Columbian Museum.

ANOTHER KANSAS METEORITE. Still another meteorite has recently been added to the list of finds and falls for which Kansas is becoming celebrated. The last reported find is from Admire, Lyon county; a stony iron of the type referred by Brezina to the Rokicky group. The only other representative of this group yet found in America, is that of Eagle Station, Carroll county, Kentucky.

The date of the fall of the Lyon county specimen is unknown, but its badly oxidized condition indicates that it has been lying in the ground for many years.

Some twelve kilograms of the material has thus far come into the possession of the National Museum at Washington, but the entire amount of the fall cannot be accurately ascertained. It will be known as the Admire meteorite.

DIFFICULTIES OF DEEP COAL MINING. In an article recently read before the North Staffordshire Institute of Mining and Mechanical Engineers (England), by Mr. Percy Turner upon the subject of "Coal Mining at Depths Exceeding 3,000 Feet," he discusses the subject under the following heads: 1st, Increase in Temperature; 2d, Increase in Pressure; 3d, Winding Difficulties; 4th, Increased Expenditure. His conclusions are as follows: "The depth, then, to which coal mines may extend depends upon human endurance of high temperatures, upon the possibility of reducing the humidity and temperature of the air, and upon the liability to gob fires. The possible working of very thick seams (from 15 to 30 feet) appears to be less than seams up to seven feet in thickness. Owing to the impracticability of completely packing horizontal thick seams, and the consequent necessity of supporting the roof with timber, and of finally allowing it to break down, instead of settling as it would if the goaf were packed, the effect of pressure becomes a serious matter. Indeed at 2,000 feet the difficulties are considerable, and at a depth of 3,000 feet, they would probably be such as to render packing impracticable.

The possible depth from which coals can be worked does not appear to be limited by any consideration of a mechanical nature. With regard to drainage, it has been proved in most Cornish mines that the volume of water does not increase beyond a certain point, with increased depth. The comparatively shallow depths intercept most of the water, leaving only a fixed quantity to deal with in the sump. In the coal fields, water is rarely if ever, met with at great depths.

The limit of depth taken by Prof. E. Hull, in 1860, and by the Royal Coal Commission, in 1870, was 4,000 feet. Prof. W. Galloway, however, says "it is probable that a depth of at least 8,000 feet will be attained, even in those localities in which the rate of increase is as much as 1 degree Fahr. in 60 feet." —*Mines and Minerals.*

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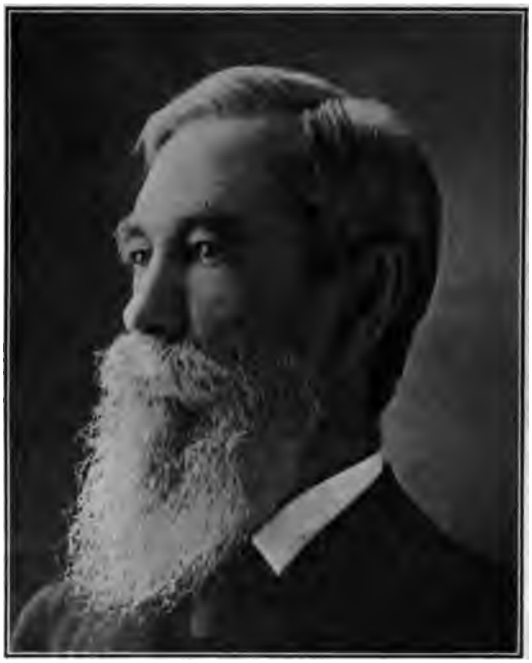

R. D. Lacoe

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RALPH DUPUY LACOE.

By Rev. Horace Edwin Hayden, M. A.,
Corresponding Secretary, Wyoming Hist.-Geol. Society, Wilkesbarre, Pa.

PORTRAIT.

Mr. Ralph Dupuy Lacoe, who died at his residence in Pittston, Penn., February 5th, 1901, was one of the few scientists in America who have attained distinction in his special department of paleontology. Indeed in this line of study the number of persons capable of filling his place immediately is very limited. Mr. Lacoe was born in Luzerne county, Pa., November 14th, 1824. He was the youngest son of Mr. Anthony Desire Lacoe and his wife Emilie Magdalena Dupuy. His father came to Philadelphia in 1792 from his home in Havre, France, under the care of Francis Gurney, the eminent merchant of Philadelphia, remaining with him four years to learn his business. Then preferring a mechanical training he bound himself to learn the business of carpenter and builder. The yellow fever, which in 1798 carried off his master's family, drove Lacoe to the Wyoming valley where he practised his trade with success until his death which occurred at the age of 103 years. The mother of Ralph Dupuy Lacoe was the daughter of an intelligent and well educated Huguenot gentlemen, Jean Francois Dupuy, who left his home in France to live in the island of St. Domingo, and was driven from there by the insurrection of 1791, locating in Wilkes Barre. Mr. Dupuy had been a man of wealth and high standing in his West India home. Charles Miner, the historian, says of him: "Jean Francis Dupuy, a French gentlemen from St. Domingo, exiled from thence by the success of the blacks, a very estimable and intelligent man, who from having been a wealthy planter, was reduced for a time to rely on personal labour; in the Masonic Lodge he forgot his misfortunes, and there, and nowhere else that I ever saw, assumed the proper station of an intelligent French gentleman, instructing and entertaining us by his philosophical views, occasionally peculiar, as well as by the numerous facts the state of the country he had lived in enabled him to give."

Mr. Ralph D. Lacoe had few advantages of education in his early youth, his mother supplying that which the country schools did not give, and with such success that before he was of age he taught school for a term or more in his neighborhood, having among his pupils the young girl who subsequently became his wife. About 1850 he and his brothers went to Nicholson, Luzerne Co., where his grandfather, Jean Dupuy's land was located; he invested in coal lands near Pittston, and when coal enterprises began to develop he engaged in the real estate business near Pittston, laying the foundation for his wealth of land and other property. In 1850, when the Pittston bank was established, he became cashier, and in 1865, when the bank was made a National Bank, he was elected vice-president. He was also president of the Wyoming Valley Knitting company in 1874, president of the Water Street Bridge company, trustee of the Miners' Savings bank of Pittston, &c., &c.

When about 1865 his health became somewhat impaired Mr. Lacoe retired from the activities of business and turned his attention to the study of geology, especially in connection with coal mining, and began to accumulate what became one of the largest collections of the fossil plants ever known. This collection was naturally divided into three departments—the Coal Flora, Fossil Insects of the carboniferous beds, and Fossils of the Paleozoic limestone beds.

This special study brought him reputation that has placed his name in the Valhalla of science with that of Lesquereux, Dawson and Cope. As his collections grew in magnitude and value the question naturally forced itself upon him as to their ultimate disposition. The pecuniary value of his work doubtless never entered his mind. He visited many public museums and institutions where such collections were preserved, but was pained with the want of attention and care given to them and hesitated to place the results of his research, and his outlay of money and study where they might some day be relegated to the shades and be forgotten.

Wisely, he determined to give his immense collection to the United States National Museum at Washington where it would do the greatest good to the greatest number. Permit me to quote the account of this unsurpassed collection published in the annual report of the National Museum: In the report of 1892. Mr. Lester F. Ward, honorary curator of this department, speaks thus:

"No gift of greater importance to the department of fossil plants has ever been made than that by Mr. R. D. Lacoe, of Pittston, Pa., under the terms of which this great collection of fossil plants is to be permanently deposited in the National Museum. The value of this collection, one of world-wide reputation, is far greater than that of the entire amount of the collections in the department prior to the date of its gift. The task of procuring fossil plants from the older formations for use in paleontological and biological research has been prosecuted for nearly twenty years by its donor whose liberal means and scientific and practical mining knowledge, as well as his favorable location in the heart of the northern arthracite coal field have enabled him to bring together an invaluable body of material, of which professor Lesquereux remarked in one of his last publications, 1886:"

"'Mr. R. D. Lacoe, of Pittston, has procured, from almost all the localities where coal is worked in the United States, an immense amount of specimens far beyond any seen even in the largest museums of Europe.'"

"Since the above quotation was written Mr. Lacoe has continued his work, having several collectors in his employ in the various states and the Acadia provinces, a portion of the material collected having been examined by professor Lesquereux. Besides gathering this material in the field he has also purchased a number of private collections, containing may type specimens, so that it is perhaps safe to say that nearly one-half of the types of the American Carboniferous flora now lie within the Lacoe collection. In fact, there are few outstanding American types except those resting in several state geological museums.

"But even the deficiency in the balance of originals has largely been compensated for by the collection of duplicates from the type localities, and these, like all other collections made prior to 1889, were examined and labelled by the original author of nine-tenths of the Paleozoic species described from the United States, Leo Lesquereux.

"How prominent a part this material has taken in both the biological and economic applications may be recognized at a glance in the three volumes of the 'Coal Flora,' report P, Pennsylvania Geological Survey, 1878-1884.

"It will at once be seen that the occasion of this invaluable wealth of material will necessarily make this institution, as a repository of the

> types of authentic species of nearly all the American Paleozoic species, the reference centre for all the extensive work on the Paleozoic flora in this country in future, as well as the custodian of valuable geological correlation data. But the proper installation in this museum of so great a collection, numbering about 100,000 specimens, is a matter involving much embarrassment in the way of space and study facilities, it being agreed in the terms of the gift that this collection, to be kept entire and known as the 'Lacoe Collection,' shall, together with all the future additions, either by exchange or gift of the donor, be kept in order and made accessible to scientists and students, without distinction, under such proper rules and restrictions as may be necessary for the preservation from loss or injury of the specimens.
>
> "The area required for the type specimens, making no allowance for increase, amounts to over 1,000 drawers the size in ordinary use in the museum. The exhibition material will occupy about 2,100 square feet. * * * * This rich possession affords just ground for national scientific pride, while the liberal public spirit with which it was given is worthy of imitation by all patrons of science." (Report of 1892, 181.)

In 1896 professor G. Browne Goode, assistant secretary of the Smithsonian Institution, said of Mr. Lacoe's gift:

> "The transfer of the magnificent Lacoe collection from Pittston, Pa., the residence of the donor, to Washington was completed during the present year. It was included in 315 boxes. * * * It is not too much to say that the National Museum has never received a gift of greater scientific value or importance than that acquired through the generosity of Mr. Lacoe." (p. 73.)

The number of original Paleozoic plant types in the museum prior to the reception of this gift was 102, the number in Mr. Lacoe's collection 575, the number of specimens 100,000. Mr. Lacoe continued until his death to enrich this spelndid collection. In 1898 he presented to the National Museum an extensive collection of fossil insects, of more than 200 types and nearly 5000 specimens. He also added over 100 invertebrate fossils, over 400 vertebrate fossils, and 132 fossil plants. Of the main collection, 804 fossil plants from the Dakota group were described with plates by Prof. Lesquereux in Monograph XVII of the U. S. Geological Survey. Among the fossil plants, Lesquereux named in honor of Mr. Lacoe eight types, *i. e.*, *Phyllites lacoei*, *Magnolia lacoeana*, *Crataegus lacoei*, *Jnglandites lacoei*, *Caulopteris lacoei*, *Cordaites lacoei*, *Lepidostrobus lacoei*, and *Stemmatopteris lacoei*. Mr. David White has also named two types after Mr. Lacoe, *Sphenopteris lacoei*, and *Alaethopteris lacoei*. In his latest *MSS.*, yet unpublished, Mr. White names a new genus, *Lacoea*.

Mr. Lacoe preferred to be student rather than a writer, but he has left the seal of his authority as an expert in his special department. Prof. J. P. Lesley, state geologist of Pennsylvania, in his geological report of Wyoming, Lackawanna and Luzerne counties, Vol. G7, Pennsylvania Survey, gives him full credit and the highest praise for his assisstance to the survey. In referring to the "Buried Valley of Wyoming" he says: "I am indebted for most of the records of drilling by the various mining companies to Mr. R. D. Lacoe of Pittston, who has done so much through his magnificent collections to advance our knowledge of the coal flora of Pennsylvania and other states."

Prof. Scudder, in his valuable work on American Fossil Cockroaches, 1895, says: "When in 1879 I published my Paleozoic Cockroaches, in which a revision of the species of the whole world was attempted, I had seen but nineteen specimens from North America belonging to seventeen species and seven genera. To-day more than three hundred American specimens have passed under my eye, besides fifty from the Triassic rocks and a very few from the Tertiary series, and from the Paleozoic series alone there are here recognized one hundred and thirty-two species belonging to fourteen genera. This recent extension of our knowledge of our Paleozoic cockroaches is very largely due to the exploitations of two localities—one in West Virginia, through the instrumentality of Mr. R. D. Lacoe of Pittston, Pa., the other in Ohio, through the labours of Mr. Samuel Huston of Steubenville, the West Virginia collection numbering 56 species and 5 genera." Prof. Scudder also describes 18 specimens of as many species in Mr. Lacoe's collection found by him in the Boston mine near Pittston. One of these was named in honor of Mr. Lacoe, "*Neymylacris lacoeana.*"

Mr. Lacoe was a Fellow of the American Association for the Advancement of Science, elected to membership August, 1882, and made a Fellow of the American Geological Society December, 1889. It was thought that he was also a member of the Geological Society of London.

In 1882 Mr. Lacoe became a member of the Wyoming Historical and Geological Society located at Wilkes Barre within ten miles of his home. His interest immediately manifested itself in a practical way by adding to its geological collections.

He became a trustee of the society in 1882 and continued one until 1889. He was also curator of paleontology in the society from 1884 to 1899, for fifteen years, when he was succeeded, at his own request, by Prof. Joshua L. Welter, the present curator. He became a life member February 8th, 1889. In 1898 he presented the society the three large cases of drawers of one hundred each which now contain the coal flora of the society, had them moved and placed in position, added largely to the specimens now forming the collection, and personally arranged them in the drawers. Of these specimens many have been identified by Prof. Lesquereux, whom Mr. Lacoe brought to the rooms for the purpose when he was visiting him in Pittston.

Of this collection Mr. Lacoe stated in his report as curator in 1886: "Many of the genera are well represented in typical series, some of which are very fully illustrated by large and fine specimens. A moderate outlay of money and well directed efforts on the part of members and friends of the society would in a short time add greatly to the value and usefulness of your collection, which already compares favorably with the best in in the country." (Proceedings, Vol. II, 160.)

Mr. Lacoe also largely aided in forming a model case in the geological room of the society, illustrating the "crust of the earth," showing its geological strata from the Archean to the Cenozoic age, a practical exemplification of the geological epochs for the use of the public schools of his section. He did not spare his own collection of fossils to enrich this model. In 1899 he presented this society with a fine collection of Paleozoic invertebrates numbering over 1,200 species and 4,500 specimens. This collection I had the great pleasure of packing, removing, and arranging, with the curator of paleontology, in the cabinet made for it, and marked, "Lacoe Collection of Fossils." A catalogue of these Fossils was published in the "Proceedings and Collections &c." of the society, 1900, Vol. V, pp. 177-204. It was also printed in a separate pamphlet entitled, "Report of the Curator of Paleontology on the Lacoe Collection of Fossils, 8vo., pp. 28, 1900."

Mr. Lacoe was married in Pittston by the Rev. N. G. Parke, D. D., April 26, 1860, to Miss Bridget Clary, who died October 31, 1872. He had four children—Josephine, who died early; Margaret Clary, now Mrs. I. S. White, of Rock Island, Illinois; Ralph Dugué, of West Pittston, and William Clary, who died young.

Mr. Lacoe was a devout Christian, baptized by Rt. Rev. Wm. B. Stevens, LL. D., 1866, confirmed by him in St. James' church, Pittston, and for many years a member of the vestry. He was also, in 1883, one of the organizers, and for years junior warden and treasurer of Trinity church, West Pittston. He was a loyal and generous churchman, liberal in his gifts, and faithful to the dear mother by whose beautiful ritual he was laid to rest. Mr. Lacoe was also a generous promoter of the Pittston Library, and in many ways, known only to the few, he delighted to aid and assist worthy objects in his town, and worthy young men to better things and nobler lives.

Mr. David White, honorary curator of Paleozoic plants (Lacoe Collection), U. S. National Museum, and an intimate personal friend of Mr. Lacoe, writes thus enthusiastically of Mr. Lacoe's relations to science.

"By the death of Mr. Lacoe science and scientists have lost a worthy and devoted friend of rare quality and strength of character. Mr. Lacoe's position in the scientific world was somewhat unusual. He was an authority on the geology of the northern anthracite coal field; his extensive knowledge in the domains of fossil plants and fossil insects was recognized on both sides of the Atlantic; his experience and observations were well supplemented by reading, and his opinions, whether concerning the structure and correlation of the Wyoming Valley coals or touching the problems of systematic paleontology, were often sought and always highly valued by specialists in paleozoölogy and paleobotany. Yet he never published more than one short article; he never described a single genus or species. So modest and unassuming was he, so small an estimate had he of his own ability and attainments, and so wholly wanting was he in the love of the notoriety of authorship, that he transferred to others for description and publication the new genera and species which he, while posing as a layman, was an expert in detecting. Always desiring that the fossils in his collection should be systematically labelled at the hands of the highest American authorities on the subject, he was accustomed, even to the last, to submit his specimens to others for study and determination. Even among the numerous representatives of the commonest and most easily recognized species, there are in his great collection comparatively few specimens whose labels show himself to have been the authority for their determination, although in the latest years of his studies of fossil plants he was himself fully competent, as far as knowledge and experience are concerned, to have determined, described and published the greater part of his paleobotanical material.

To the scientific world in general, beyond the circle of his personal friends and acquaintances, Lacoe was widely known as a promoter or patron of science; and it was in this capacity that he did his greatest and best work. The occasional collecting of fossils, begun as an out-of-door recreation beneficial to his failing health, quickly developed a profound and enthusiastic interest in th plant-life of earlier geological time and the remarkable discoveries resulting from paleontological research. At first he made extensive collections of coal plants from the Wyoming Valley coal field. Realizing at an early date the very great handicap to the progress of paleontology resulting from the enormous labor and expense of exhuming, intelligently collecting and bringing the raw fossil material to the hand of the paleontologist, he chose, for his part and service, to promote the advancement of science by gathering the materials for and facilitating the work of the paleontologist. Accordingly, he began systematically to procure, through the aid of collectors, by purchase, exchange, or with his own hands, collections to show the plant life in various geological epochs, but chiefly Paleozoic, in different countries and continents, as well as from the coal fields of this country. Becoming interested in the occasional remains of insects, which, very rare at best, are seldom discovered except in their natural association with fossil plants, Lacoe also entered upon the systematic collection of fossil insects and crustacea as well."

"Lacoe's aid to science did not end with collecting the fossils and placing them in the hands of the appropriate specialists. Whenever a paleontologist was so situated as to be dependent on his daily labor for his livelihood, Lacoe made it possible for him to carry on his researches in the material placed in his hands. In many additional cases the expense of preparing suitable drawings, so essential in paleontological publications, was also borne by him. It deserves to be added, to the disgrace of a State great in many respects, that in order that the invaluable data of the Lacoe collections relating to the geographical and stratigraphical distribution of the species might be included and made available in the Pennsylvania state geological report on the Coal Flora; that the stratigraphic and correlative values of the species might be ascertained and the described species made satisfactorily recognizable by means of adequate illustration, Lacoe largely bore the expenses of the paleontological study of the collections and guaranteed the compensation for a part of the illustrations. He was further the benefactor of the State through the presentation of extensive series of specimens to its geological museum. He was also bearing the expense of the paleontological study and of the preparation of manuscript and illustrations of the materials to form a supplementary volume of the Coal Flora to be published by the State, when the failing health and death of Prof. Lesquereux left the work incomplete. Before the resumption and completion of the work the state survey was abolished."

Single handed and with but slight aid among his friends, Lacoe quietly did for science a work of a kind that is rarely prosecuted except by the wealthier universities, endowed scientific societies, or special scientific institutions. His extreme modesty regarding the importance and value of his collections, and the patriotism shown in the disposition of the results of so great personal labor and care, are a moral object lesson to wealthy patrons of science.

"The greatest and most enduring monument to Lacoe's devotion to and work for science is the Lacoe collection. Carefully guarded against danger or deterioration, it will be increased in numbers from time to time by exchanges or additional gifts. Visitors to the paleontological halls of the Nation's Museum may see an exhibit comprising a small portion of the more imperishable and attractive specimens of 'The Lacoe Collections,' the greater number studied and identified by the foremost paleontologists of the time. Its types, from the hands of Lesquereux, Dawson, Scudder and Cope, will be consulted and re-examined by the savants of paleontology for centuries to come. Students of life distribution, climate and of evolution will review its suites of specimens, and their records will supplement the records of the great paleontologists of the past who have participated in its original elaboration. These records are in the paleontological literature of every land; and while there shall remain a literature or a human interest in paleontology, the name and scientific service of R. D. Lacoe will be perpetuated. The collection tells its own history; it tells of its author's intense interest and devotion, and of his great personal labors and aid in behalf of paleontology and geology; by the notes and inscriptions, the patient and loving care in registration, the comments and remarks it tells of its relations to the students, of congenial scientific discussions, and of warm and lasting friendships between paleontologist and patron, welded on the fossil anvil. The best, the most lasting scientific memorial of our friend and fellow is the great Lacoe collection."

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List of Palæozoic Fossil Insects of the United States and Canada, Alphabetically Arranged, Giving Names of Authors, Geological Age, Locality of Occurrence, and Place of Preservation, with Reference to the Principal Bibliography of the subject. A Paper Read Before the Wyoming Historical and Geological Society April 6, 1883. By R. D. Lacoe. (Seal of the Society. Publication No. 5, 8vo, pp. 21, Wilkes-barre, Pa. Printed for the Society. 1883.

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THE LOESS OF IOWA CITY AND VICINITY.[*]

By B. Shimek, Iowa City, Iowa.

The loess of Iowa City presents no unique features. It is of the type which prevails in the eastern part of the state, being fine and homogeneous; found chiefly on highlands, especially in its undisturbed condition, and following their vertical contours, thus varying but little in thickness which seldom exceeds twelve or fifteen feet; containing both tubules and loess-kindchen in the usual varying proportions; and more or less fossiliferous. It has been quite fully discussed by McGee[†]. Lists of the fossils which are found about Iowa City have already been published,[‡] and it is not the purpose of this paper to offer much that is new in this direction, but rather to present a detailed account of the habits of the local modern molluscs, and their bearing on the loess.

In probably no other locality in the country have these modern and loess faunas been studied side by side more fully than at Iowa City. Besides the early work of Witter, and that of Keyes (chiefly upon State University Museum specimens collected and identified by the writer), the efforts of Pilsbry and Bayard Elliott were especially noteworthy, though the former published but little, while the latter made no permanent record of his observations, but submitted a part of his collection to the present author, who has been engaged in loess and mollusc studies with more or less interruption for many years, and has gathered together great numbers of both fossil and modern forms which bear on this question.

The lists representing these faunas are therefore more complete than is possible where resident observers are not engaged in the investigation of both branches of the subject, and this fact, coupled with the comparative richness of both faunas, makes a comparison of them especially interesting and suggestive. Since all of the fossils which have been found at Iowa City are molluscs, and belong with few exceptions to the local modern molluscan fauna, a study of the habits of the living species is of the highest importance because of the light which is thus thrown upon the conditions which existed during the deposition of the loess. The species included in this list are therefore grouped according to habit in order that comparisons and conclusions may be facilitated. All notes on distribution, etc. of both modern and fossil shells in the following list have reference to the vicinity of Iowa City only, unless otherwise specifically stated. "Western loess" means that of western Iowa and eastern Nebraska. The material was abundantly collected and studied in the field by the author, and is now in his private collection.

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[*] Excerpt from the *Bulletin* of the Laboratories of Natural History, State University of Iowa, vol. v; No. 2, pp. 195-216.

[†] *U. S. Geol. Sur.*, vol. xi, pt. i, 1891.

[‡] W. J. McGee, *l. c.;* C. L. Webster, *Am. Nat*, May; 1887, p. 419; B. Shimek, *Am. Geol.*, vol. i, pp. 149-152, 1888; *Bull. Lab. Nat. Hist.*, State Univ. Ia., vol. i, pp. 200-209, 1890; etc.

The names of the local fossil (loess) species are preceded by two asterisks. Those which have been found fossil in the loess in other localities, but not at Iowa City though now found living here, are marked by one asterisk. The latter series does not however include all the species of the modern fauna of Iowa City which were reported in the earlier Missouri and Nebraska lists of loess fossils, as no specimens are extant and the species are not now known to occur in undoubted loess. The species living near Iowa City but not represented in the loess are unmarked. The territory covered by this report is included within a radius of six miles from Iowa City.

RECENT AND FOSSIL MOLLUSCS AT IOWA CITY.

I. SPECIES HERE FOUND ONLY AS FOSSILS.

PYRAMIDULA SHIMEKII (*Pils.*) *Shim.*

Quite common in the loess of Iowa City, which furnished the type specimens. A more complete discussion of this species is given on pp. 139-145 of this Bulletin.

PYRAMIDULA STRIGOSA IOWENSIS *Pils.*

This variety is now extinct. All other forms of this extremely variable species however belong to the dry western plateaus and mountains. It is locally quite common in the loess, and the type specimens were from this locality.

**PUPA MUSCORUM (*L.*).

Now living in the U. S. from Maine to Montana, thence to Nevada. Also in Europe. Not rare in the loess.

**Pupa blandi (*Morse*) *Binn.*

Two specimens were recently found in the loess near Iowa City. It is not rare in the western loess, and is found living from New Mexico to Montana. The shells usually formerly reported under this name are *Bifidaria pentodon*(*?*). The easternmost localities from which fossils have been received are Muscatine and Stockton in Muscatine county, Iowa. They were erroneously reported as *P. muscorum.**

**Vallonia gracilicosta *Reinh.*

Quite common in the loess. It is common in western and northwestern Iowa, and thence westward, where it lives in high, dry situations. Its easternmost known station in Iowa is in Winnebago county.

**Succinea grosvenorii *Lea.* (*?*)

A form referable to this species is quite common in the local loess. The species now lives abundantly in the South, and in Nebraska and western Iowa, and is uniformly found (so far as the writer's experience shows) in situations which are exposed to severe drouth during at least a portion of each year.

The Succineas of this group, both recent and fossil, require further elaboration.

It is interesting to note that the foregoing species, now extinct at Iowa City, all belong to the modern terrestrial fauna of the dry west, from Montana to New Mexico, and that only two species extend eastward as far as Iowa.

2. Terrestrial species, now living at Iowa City.

a. Species of higher, more or less exposed, and often rocky slopes..

*Vallonia parvula *Sterki.*

Common on exposed rocky slopes, hence occurring in scattered colonies. Rare in the loess of western Iowa.

*Leucocheila fallax (*Say*) *Try.*

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*Through the writer's error they were reported in Prof. Udden's, note on Hershey Ave. fossils in Leverett's Report in *U. S. Geol. Sur.*, vol. xxxviii, p. 174, 1899. In that list *P. blandi* should be substituted for *P. muscorum*. Also in Udden's Report, *Ia. Geol. Sur.*, vol. ix, p. 359, 1899, where the same substitution should be made in the Fulton township (Stockton) list. *P. muscorum* does however occur at Muscatine.

Locally common on higher exposed slopes, chiefly under fragments of limestone. Rare in the loess of western Iowa and eastern Nebraska.

**BIFIDARIA ARMIFERA (*Say*) *Sterki.*

Very common. Most frequent on more or less exposed slopes under limestone, among roots of grasses, etc. Sometimes also in deeper shade, and occasionally on lower grounds, under logs, etc. Rare in the loess at Iowa City, but very common in the western loess at Council Bluffs, Iowa.

*BIFIDARIA HOLZINGERI (*Sterki*).

Quite common under stones, etc. on exposed hillsides. Rather rare in western loess.

**BIFIDARIA PENTODON (*Say*) *Sterki.*

Quite common on rather open rocky slopes, sometimes on lower grounds, under stones, etc. As a fossil this species is widely distributed, and in this locality is very common.

*BIFIDARIA CURVIDENS (*Gld.*) *Sterki.*

Not uncommon. It is rare in the loess of the west and south, but has not been found fossil at Iowa City.

*BIFIDARIA CORTICARIA (*Say*) *Sterki.*

Common in a few restricted localities among the roots of tufted grasses, etc. growing on exposed rocky slopes. Not found in the local loess, but reported from Des Moines by Keyes, from Muscatine by Witter and from Illinois by Leverett. It is not rare in the loess of Natchez, Miss.

*POLYGYRA LEAI (*Ward*) *Pils.*

Found here under sticks, etc. on slopes near a prairie swamp. Also more rarely on scantily wooded slopes. Rare in the loess of the west, etc.

*SUCCINEA AVARA *Say.*

Not rare on more or less exposed rocky slopes. This is the small, typical form which is now found on low grounds. The same form occurs abundantly as a fossil, being one of the most characteristic species of the loess. It occurs in all the fossiliferous exposures near Iowa City, being the only fossil found in some of them.

**VITREA INDENTATA (*Say*) *Pils.*

Not rare on rocky slopes. This, and the following species, also occur on lower grounds, but both are more common on drier slopes. Rare in the loess.

**ZONITOIDES MINUSCULUS *(Binn.) Pils.*

Common under stones, etc. on higher slopes, and under sticks, leaves, etc. on lower grounds. Rare in the loess.

b. Species of higher, more deeply shaded (often mossy and rocky) banks and slopes, sometimes in deep woods.

**HELICINA OCCULTA *Say.*

This species, though a prosobranch, is strictly terrestrial in its habits. It is found living in but one locality, a steep, rocky northern slope near Turkey creek, six miles north of Iowa City, the locality in which it was first discovered by the writer about twenty-two years ago. It is quite abundant in this very restricted locality, being found under stones and fallen leaves. It is very common in the loess, and is found in nearly all the exposures. The body-whorl of the fossil shell sometimes still contains the operculum.

The writer recently found this species (living) common on the rocky slopes along Pine Hollow creek in Dubuque county, and Little Turkey river and its small tributaries in Clayton county, Iowa localities not hitherto reported.

**POLYGYRA PROFUNDA *(Say) Pils.*

Common under sticks, stones, leaves, etc. on higher shaded slopes. It is found in but one loess-exposure in this vicinity, but is very common in the loess of Natchez, Miss.

*POLYGYRA CLAUSA *(Say) Pils.*

Widely distributed in deeper woods near Iowa City, but nowhere common. As a fossil it is rare, occurring occasionally in more southerly loess. None have been found at Iowa City.

*POLYGYRA HIRSUTA *(Say) Pils.*

Locally quite widely distributed in deeper woods, though never gregarious. Fossil shells are found sparingly in the western loess at Council Bluffs, Iowa.

*POLYGYRA MONODON *(Rack.) Pils.*

This species is very similar to the preceding in its habits, and in the distribution of both the recent and fossil forms, both, however, being rather more abundant. Neither has been found fossil at Iowa City, though their discovery would not be surprising. Common in the loess at Natchez, Miss., and also fossil in Indiana.

*STROBILOPS VIRGO (*Pils.*).

Locally common on rocky, shaded slopes. It is occasionally found fossil in the western loess. This has ordinarily been reported as *Strobila labyrinthica* Say.

VERTIGO MILIUM (*Gld.*) *Binn.*

Not common, on mossy banks and slopes. Not found fossil. Its minute size might easily cause it to be overlooked.

**VERTIGO OVATA *Say.*

Rare, on mossy, shaded banks, sometimes on lower grounds. Somewhat more common as a fossil, occurring sparingly in several of the exposures.

*VERTIGO BOLLESIANA (*Morse.*)

Rare, on mossy banks, usually in shady places. It is rare in the western loess.

*VERTIGO TRIDENTATA *Wolf.*

Locally common, usually on rather exposed rocky, moss-covered banks. Found sparingly in the western loess.

**COCHLICOPA LUBRICA (*Müll.*).

Rare on rather open slopes, etc. It is more common as a fossil, but is one of the rarer species of the local loess.

*CIRCINARIA CONCAVA (*Say*) *Pils.*

Widely distributed on shaded, especially rocky, slopes, but not gregarious. It is not found in the local loess, but is quite common southward. It is one of the common fossils at Natchez, Miss.

**CONULUS FULVUS (*Drap.*) *Müll.*

Not uncommon on shaded slopes in moss, and under sticks, leaves, etc. Fossil shells are not rare, and as a rule are better developed than the modern specimens.

*ZONITOIDES ARBOREUS (*Say*) *Sterki.*

Very common, usually under logs in high or low places, and not uncommonly in comparatively open woods. It can not yet be reported from the local loess, but has been found by Prof. Savage in the loess of Henry county, Iowa, and it is not rare in the western loess.

**PYRAMIDULA ALTERNATA (*Say*) *Pils.*

Locally common, usually on higher, deeply-shaded slopes under logs, stones, leaves, etc. Not common in the loess at Iowa City.

**PYRAMIDULA PERSPECTIVA (*Say*) *Pils.*

Common on shaded banks, etc. under decaying logs. This species is not generally distributed in the loess, though it is very common at Natchez, Miss. At Iowa City it occurs rather abundantly in but one exposure.

**HELICODISCUS LINEATUS (*Say*) *Morse.*

Scattered specimens are not infrequent. They are usually found in deeper shade under sticks and logs. Fossil shells are quite rare.

*PUNCTUM PYGMAEUM (*Drap.*) *Binn.*

This minute shell is easily overlooked, but is quite common under sticks and fallen bark on northerly shaded slopes, and among clumps of hazel, etc. on lower grounds. The author collected fossil shells in the loess of Natchez, Miss., but none have yet been found in the northern loess.

**SPHYRADIUM EDENTULUM ALTICOLA (*Inger.*) *Pils.*

While this form scarcely deserves rank as a variety, the name is here retained to designate the common loess fossil which is identical with recent shells (commonly known under the varietal name) which are now found in Wyoming, Colorado, etc. This form is much elevated, and has a distorted body-whorl, which destroys the symmetry of the otherwise almost perfectly cylindrical shell. Typical *edentulum* is exactly like the upper part of the shell of the variety and is a less fully developed form. An occasional shell of the varietal form is found eastward with the type. Speaking of the recent shells Dr. Sterki says:* "There are, among the common form, high specimens with narrower penultimate and wider last whorl, found everywhere occasionally in this country as well as in Europe; and thus *P. alticola* Inger.† is not even a true var. here."

However in the Rocky Mountain region the variety is the common form, and it is likewise generally distributed through the northern loess, belonging to the category of the most common and most characteristic loess fossils.

Only two recent specimens have thus far been taken at Iowa City. As both are rather young shells it is impossible to determine whether they are the type or the variety. As the distinction between them, however, is not worthy of maintenance, they are here grouped together.

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*Nautilus, vol. vi, pp. 6 and 7, May, 1882.

†First described as *Pupilla alticola* Ingersoll, in *Bull. U. S. Geol. Sur. of the Ter*., 2, p. 128, 1875.

c. Terrestrial species of lower, shaded, alluvial grounds, under sticks, leaves, etc.

**POLYGYRA MULTILNEATA (*Say*) *Pils.* (Large form).

Two forms of this species occur here. The larger, the more common form, lives on wooded alluvial bottom-lands which are not too dry, and may be found abundantly creeping or hiding among the smaller plants, under fallen leaves, etc. Four fossil specimens only were found in one of the exposures at Iowa City, and it is rare in the loess of the Missouri river in eastern Nebraska. The smaller form, discussed under (*d*), is much more common in the loess.

*BIFIDARIA CONTRACTA (*Say*) *Sterki.*

Very common on rather low grounds, under logs, etc., sometimes ascending to higher slopes. Absent from the local loess and rare westward. It is more common in the southern loess.

BIFIDARIA PROCERA (*Gld.*) *Sterki.*

Only one local specimen was collected on rather low ground. Westward this species is quite common in drier situations, under sticks and leaves in clumps of bushes, etc. None have yet been found in the loess.

**VITREA HAMMONIS (*Strom.*) *Pils.*

This name is used for the species commonly known as *Zonites viridulus* Mkc. on the authority of Pilsbry. Binney refers *Helix hammonis* Ström. to *Zonites fabricii* Beck,—a species from Greenland.* Our species is quite common under logs, etc. on rather low, more or less wooded, grounds. Rather rare in the local loess, but more common westward.

**PYRAMIDULA STRIATELLA (*Anth.*) *Pils.*

Quite common on scantily timbered alluvial bottom-lands, under logs, fallen leaves, etc. Also on higher slopes. As a fossil it is very common, and is widely distributed, appearing almost universally in our northern loess deposits. Fossil eggs, agreeing exactly with recent eggs of this species, are also frequently found.

**SUCCINEA OBLIQUA *Say.*

Very common under leaves; etc. on timbered alluvial bottom-lands. Westward the species frequently appears on higher grounds. Quite common as a fossil.

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*W. G. BINNEY, *Terr. Air-Breath. Moll. U. S.*, vol. v, p. 127, 1878.

*Carychium exiguum (*Say*) *Gld.*

This species is common in damp places on rather low grounds, under logs, etc. No local fossil specimens have been found, but the species is rare in the western loess.

*Pomatiopsis lapidaria (*Say*) *Try.*

Locally common with *Pyramidula striatella.* This species, like *Helicina occulta* is a gill-bearing mollusc, yet it is strictly terrestrial in its habits. The author has collected living specimens in widely separated sections of the State, and found the habitat uniformly the same. Not found in the local loess, but reported from Memphis, Tenn.,[*] from Missouri[†] and from Arkansas.[‡]

While the species of this group are more common on lower grounds, most of them occasionally appear on higher slopes. Thus *Polygyra multilineata* (medium sized), *Bifidaria contracta, Vitrea hammonis, Pyramidula striatella* and *Succinea obliqua* are very common on a rather scantily wooded, rocky, steep slope in Iowa City at an altitude of from twenty-five to seventy-five feet above the Iowa river. Most of these species also occur sparingly at higher altitudes in the western part of the State. *Bifidaria contracta* is so common in such situations in all parts of the State, that it might well be classed in group (*b*).

d. Species of mud-flats, edges of swamps, etc.

Zonitoides nitidus (*Müll.*) *St.*

This species is locally not uncommon under sticks and leaves in low, wet places. It has not been found in the loess.

**Polygyra multilineata (*Say*) *Pils.*

The smaller form, already mentioned, is not uncommon along the edges of a prairie swamp near Iowa City. It is almost exactly like the locally more common fossil form of this species. This small form is also common in other portions of the State,—especially westward.

*Succinea retusa *Lea.*

This species is now common on mud, etc. among plants in swampy places. The large variety *magister* Pils. is the common form. A few fagmentary specimens of young shells from the loess of Nebraska are in the writer's possession. They are probably young shells of the variety. None have been found at Iowa City.

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[*] James M. Safford: *Geol. Tenn.*, p. 434, 1869. Reported as *Amnicola.*

[†] G. C. Swallow: *Geol. Sur. of Mo.*, vols. i and ii, p. 215. Also reported as *Amnicola.*

[‡] R. E. Call: *Rep. Ark. Geol. Sur.*, vol. ii, pp. 166, 167 and 179.

**SUCCINEA ———*sp.* (?).

A rather large *Succinea,* which has not yet been satisfactorily placed, is quite common on bare mud-flats along streams, and also occurs in the local loess. In some respects it is intermediate between *S. avara* and *S. obliqua,* sometimes approaching the smaller, more slender forms of the latter species quite closely.

The foregoing species are wholly terrestrial in habit, and moreover, with few exceptions flourish in comparatively dry situations. While all require a certain amount of moisture when active, the lower surface of a fallen leaf, a stick, or a stone, even in a comparatively exposed place, furnishes all that is necessary.

The following summary of the preceding notes is of interest:

Species found at Iowa City only as fossils	6
Species found here both living and fossil	19
Species now found living here, but occurring as fossils in the loess of other localities	19
Species living here, but not yet reported from the loess	3
Total	47

These shells represent more than 90% of the fossils in the loess, and, the fossil fauna so far as it occurs, is very similar to the living surface fauna. The latter is richer in species, but this difference may be only apparent. A close study of the local living fauna shows that species frequently occur in very restricted areas. Different parts of the same slope, often but a few feet apart, not infrequently show much variation in the distribution of species. When we take this peculiarity of distribution of land-shells into account with the comparatively very small total area of all the loess exposures of this vicinity, we can readily see that the opportunities for finding the recent shells are much better.

While, as stated, the great majority of the local loess fossils belong to the preceding list of terrestrial forms, a few additional species of aquatic habit are also sparingly found. In no case, however, are they generally distributed in the loess, and with the possible exception of *Limnaea caperata* and *L. humilis,* very few individuals are found. In order that the comparative scantiness of the fossil aquatic molluscan fauna may be more fully appreciated a list of the local aquatic species is here given. Those which also occur in the local loess are marked by two asterisks, and those which are positively known as fossils only from other localities are marked by one asterisk.

2. AQUATIC SPECIES NOW LIVING AT IOWA CITY.

a. Species of smaller ponds, etc., which often become dry in summer.

*LIMNAEA REFLEXA *Say.*

Common some years in shallow ponds. Not found in the loess of Iowa and Nebraska, but reported from Missouri by Hambach.*

**LIMNAEA CAPERATA *Say.*

Locally very common. As a fossil it occurs in but few exposures, and in these is usually restricted to narrow bands or pockets, in which it is quite abundant.

**LIMNAEA HUMILIS *Say.*

Very common in shallow ponds, or on mud-flats. As a fossil it occurs with the preceding species, and is even more common.

**LIMNAEA DESIDIOSA *Say* (?).

Some of the smaller fossil shells of *Limnaea* may belong to this species. It is probably found in the loess westward, though in some cases at least the fossils reported under this name undoubtedly belong to the preceding species. Common in shallow ponds.

**PHYSA GYRINA *Say.*

Very common in shallow ponds. Two very small specimens, probably this species, were found in the loess at Iowa City.

PHYSA INTEGRA *Hald.*

Very common in ponds, etc. Hitherto reported as *P. heterostropha* Say. In a very large series of shells from Iowa and Nebraska not one specimen of the latter species was found.

**Geol. Sur. of Mo.*, Bull. No. 1, p. 82, April, 1890.

PHYSA SAYI *Tap.*

Quite common locally. None fossil.

PLANORBIS CAMPANULATUS *Say.*

Rare locally in ponds. None fossil.

*PLANORBIS TRIVOLVIS *Say.*

Very common in shallow ponds. Reported from Missouri, but, if occurring at all, certainly not common.

*PLANORBIS BICARINATUS *Say.*

Common in shallow ponds. One fossil specimen was collected by Prof. Beyer at Ames, and the species has been reported from the loess of Tennessee.*

PLANORBIS EXACUTUS *Say.*

Locally common in shallow ponds.

*PLANORBIS PARVUS *Say.*

Very common in ponds, etc. Rare in the western loess.

*PLANORBIS ALBUS *Muell.*

Quite rare in rather more permanent ponds. Prof Udden collected one specimen in the loess of Milan, Ill.

PLANORBIS DILATATUS *Gld.* (?).

Locally rather frequent. None fossil.

*SEGMENTINA ARMIGERA (*Say*) *H. & A. Ad.*

Common in ponds. Reported from the loess of Missouri, but not known as a fossil in Iowa and Nebraska.

ANCYLUS DIAPHANUS *Hald.*

Common on sticks, etc. in more permanent ponds.

*VALVATA TRICARINATA (*Say*).

Quite common. It also occurs in deeper ponds. Prof. Udden collected it in the loess of Milan, Ill., and it is reported from Missouri. It is, however, very rare as a fossil.

PISIDIUM COMPRESSUM *Prime* (?).

A few valves of this, or a closely related species, were found in the local loess. The species is now common, especially westward, in small prairie streamlets, etc.

All but the last two species in this list are air-breathing forms. The last one is a bivalve.

b. Species of deeper ponds, bayous, etc.

GASTEROPODS.

BITHYNELLA OBTUSA (*Lea*) *St.* Quite common.

AMNICOLA CINCINNATENSIS (*Anth.*). Very common.

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*SAFFORD, *Geology of Tenn* , p. 434, 1869.

heavy, and often large. Had large streams or other bodies of water existed where the loess is deposited, thus furnishing conditions favorable to this fluviatile fauna, it is reasonable to suppose that some of these shells would be found fossil today to relate the story of the conditions under which they existed. Yet no such evidence has ever been found in undoubted undisturbed loess, and the conclusion that such bodies of water did not exist where loess is now found is irresistible. Indeed the molluscan fauna of the loess points to comparatively dry, upland, terrestrial conditions such as exist over the greater part of Iowa today. It suggests land-surfaces clothed with vegetation offering shelter and food to terrestrial snails,—a vegetation developed under medium conditions of moisture and temperature such as exist here today.

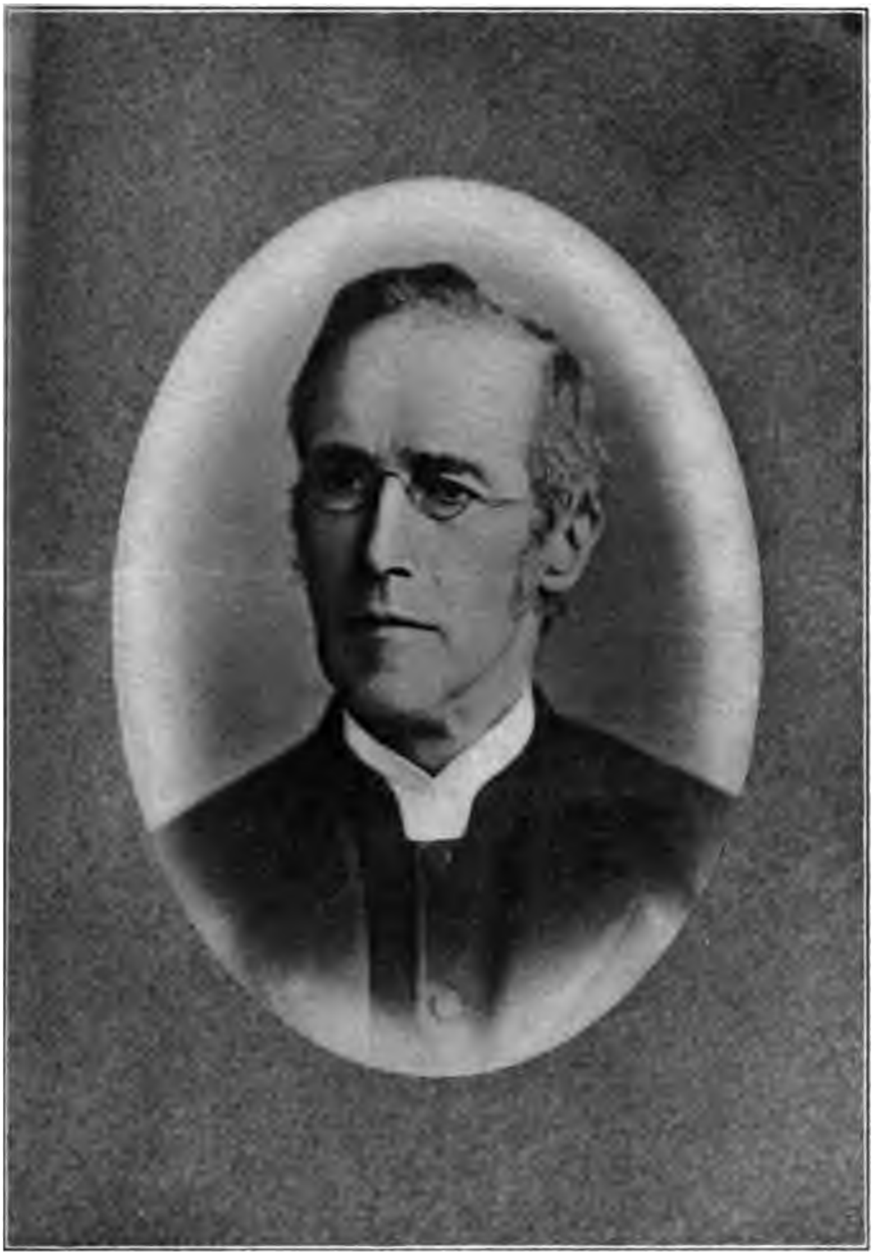
PROF. W. H. BARRIS.

By C. H. Preston, M. D.

PORTRAIT.

Willis Hervey Barris, D. D., scientist, educator and churchman, died at his home in Davenport, Iowa, June 10th, 1901, having almost completed his eightieth year. Senior priest of the Episcopal Diocese of Iowa and Curator of the Davenport Academy of Science at the time of his death, the close of a long and useful life found him still at work, as always, to the extent of his strength, in the conscientious discharge of duty.

Born in Beaver county, Pennsylvania, July 9, 1820, he entered Alleghany college, Meadville, Pennsylvania, at the age of fourteen; received the degree of A. B. in 1839, and completed a post graduate course in civil engineering in 1841. In 1854 his alma mater conferred on him the degree of A. M. His career in Alleghany college said its president, Dr. Baker, "Was equally honorable to the college and to himself." He was "an excellent scholar in every department of the college course," with a "decided penchant for scientific pursuits." At the age of twenty-one he entered upon a course of theological study and was graduated from the General Theological Seminary, New York City—the oldest Protestant-Episcopal theological school in the United States—in 1850.



Very truly yours
W. H. Barris

HE AMERICAN GEOLOGIST,
VOL. XXVIII. PLATE XXXIII.

[illegible] LIBRARY

ASTOR, LENOX AND
TILDEN FOUNDATIONS

Ordained priest by bishop De Lancy of New York, he became rector of St. Luke's church, Brockport, N. Y., in 1852, and later served as assistant to Rev. Henry Lee (afterward first bishop of Iowa) at Rochester, N. Y.

Coming to Iowa at the solicitation of bishop Lee, who recognized in him qualities of a high order, he became rector of Trinity church, Iowa City, in 1855, and of Christ church, Burlington, in 1859, whence, after seven years of arduous labor and study, he was called to the Ely professorship of ecclesiastical history in Griswold college, Davenport, which city was thereafter to be his home.

It was as a personal compliment to Dr. Barris, and to secure his services permanently for the college, that the Ely endowment was made and conditioned on his having a life tenure in Ely house, the home at Twelfth and Main streets, where he breathed his last. His personal popularity and recognized ability as an instructor helped largely to give to the theological department of Griswold, its high educational standing during the more than twenty years he spent in its service.

Many men, now prominent in the church, were members of his theological classes and credit him in large measure with the success attending their labors. Always modest and unassuming, himself setting the example of faithful work, he was loved and revered by his students, one of whom feelingly writes: "He was the most helpful man I ever met," "I doubt if there is one who does not bless the day that he came under the influence of the mind and heart of Willis H. Barris."

He had chosen the church as his life work and gave it his first allegiance, consequently when offered a chair in the Iowa state university, he declined, saying: "Paleontology is my play, theology is my work." Nevertheless, wherever his lot was cast, he at once identified himself with all the higher intellectual interests of the community about him, and supplemented his work for the church by a thorough study of the geology and paleontology of the region.

By numerous short excursions and occasional longer journeys, he collected material and observations which, with his scholarly interpretation, gave results of great scientific value.

At Iowa City he made a close study of the Hamilton and other Devonian rocks. At Burlington he found a rich field in the crinoids and other fossils of the Burlington limestone, of which he made a large and valuable collection, discovering many new species. Some of these are described in his own written contributions to science; others, by his permission, were named and described by Dr. Hall, Mr. Wachsmuth, Dr. Knapp and other leading geologists, who personally acknowledged the value of his work. Many of the new forms described and pictured in Wachsmuth and Springer's great work on the crinoids, were first discovered by Dr. Barris. Through Wachsmuth also, many specimens were sent to the British Museum, in acknowledgment of which a copy of the beautiful "Catalogue of the Blastoidea" (Etheridge and Carpenter, London, 1886) was sent to him by the trustees of the museum. Next to Wachsmuth, Dr. Barris is named first among the scientific friends at home and abroad to whom its authors express their indebtedness.

In the summer of 1866, professor and Mrs. Louis Agassiz visited Burlington purposely to see the Barris collection of crinoids, and were so delighted with it that negotiations were opened at once and it was purchased for the museum at Cambridge. In a subsequent letter professor Agassiz writes: "I owe it to you to say that I shall treat this collection with all the regard which it deserves, and that I shall take good care to have the scientific world know and understand that while it will become an ornament to the museum at Cambridge, it is yet entirely your work. Every specimen shall be furnished with a label stating that it once formed part of your collection, and I believe I am within bounds in saying that it will commemorate your scientific zeal and ability as surely as it would remaining in your possession. Allow me to request you, therefore, not to feel as if you had parted with your interest in science, but on the contrary to continue your efforts in a direction in which you have thus far been so eminently successful."

On removing to Davenport Dr. Barris still kept up his geological studies, contributing, from time to time, valuable articles for publication, chiefly in the Proceedings of the Davenport Academy of Science. He became a member and was made a trustee of this institution at its first meeting, and was active in its support through life. Elected president in 1876, in 1890 he took up the work of caring for its museum and correspondence laid down by his friend, curator Pratt, and despite an affection of the eyes, at times excruciatingly painful, discharged faithfully the onerous duties of the place to within a few days of his death.

The loving regard in which he was held by his associates in the academy was thus expressed in resolutions of respect to his memory: "Of a gentle and scholarly disposition, holding close and loving communion with nature's visible forms and their informing Spirit, he had neither time nor inclination for business strife with his fellow men. The soul of kindliness in every relation of life, he made each one who came to know him a friend." To the writer, who knew him well, he embodied the highest ideal of kindly. courteous and Christian manhood. In him were united a soul pure as a child's, the modesty of great wisdom, and the simply dignity of a gentleman of the old school.

Davenport, Iowa, October 21, 1901.

A SECTION OF THE UPPER ORDOVICIAN AT VEVAY, INDIANA.

EDGAR R. CUMINGS.

PLATES XXXIV AND XXXV.

The detailed section described in the present paper is published, without the faunal lists, in a paper by the writer, in the Proceedings of the Indiana Academy of Science for 1900. It is proposed here to supplement the stratigraphic details already given, by an analysis of the faunas.*

The section begins at the level of the Ohio river at Vevay, Indiana, and includes beds ordinarily correlated with the Utica and Lorraine of the eastern United States. The lowest exposures occur at the foot of a glen or run opening out on the flood plain of the Ohio river, upon which the city of Vevay is built, at the head of "Main cross" street, just east of the orphan asylum. The section extends up the glen to near the top

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*The identifications of the Bryozoa listed in this paper are invariably based upon thin sections.

5. *Coeloclema alternatum* (James) (a).
6. *Bythopora arctipora* (Nicholson) (c).
7. *Leptotrypa* cf. *Calceola* (Miller & Dyer) (rr), a fragment from which the shape of the zoarium could not be made out. The internal characters are those of the species *calceola*.
8. *Dekayella ulrichi* (Nicholson) (c). Large form.
9. *Dalmanella multisecta* (Meek) (c).
10. *Plectambonites sericeus* (Sowerby).
11. *Zygospira modesta* (Hall).
12. *Calymene callicephala* (Green).
13. *Proetus* sp.
14. *Conchiolites* sp.
15. Crinoid segments of several species. (c) This layer is probably the equivalent of the base of XI *b* of Ulrich's Cincinnati section.

No. 12. Shale with occasional thin layers of limestone, 6 feet 4 inches.

No. 13. Compact limestone, 5 inches.

1. .*Coeloclema alternatum* (James) (c).
2. *Bythopora arctipora* (Nicholson) (c).
3. *Callopora onealli-sigillaroides* (Nicholson)
4. *Dekayella ulrichi* (Nicholson).
5. *Arthropora* sp.
6. *Leptotrypa* sp.
7. *Callopora onealli-communis* (James).
8. *Rafinesquina alternata* (Con.).
9. *Dalmanella multisecta* (Meek).
10. *Calymene* small fragment.
11. *Zygospira modesta* Hall.
12. *Batostoma implicatum* (Nicholson).
13. Crinoid segments. *Heterocrinus?*

No. 14. Shale, 5 inches.

No. 15. Compact limestone, 6 inches.

1. *Eridotrypa vevayensis* n. sp.
2. *Dekayella obscura* Ulrich.
3. *Callopora onealli* var.
4. *Bythopora* sp.
5. *Escharopora acuminata* (James)?
6. *Dekayella ulrichi* (Nicholson).
7. *Rafinesquina alternata* (Conrad).
8. *Dalmanella multisecta* (Meek).

No. 16. Shale, 2 feet 6 inches.

No. 17. Limestone, 3 inches.

1. *Callopora onealli-sigillaroides* (Nicholson).
2. *Batostoma implicatum* (Nicholson).
3. *Peronopora vera*.
4. *Bythopora arctipora* (Nicholson).
5. *Dalmanella multisecta* (Meek).

6. *Rafinesquina alternata* (Conrad).
7. *Zygospira modesta* Hall.
8. *Plectambonites scriceus* (Sowerbv) (rr).
9. *Calymene callicephala* Green.
10. Crinoid stems.

No. 18. Shale, 7 feet.

No. 19. Thin layers of limestone, intercalated with shale, 1 foot.

1. *Peronopora vera.*
2. *Bythopora* sp.
3. *Dalmanella multisecta* (Meek) (aa).
4. *Rafinesquina alternata* (Conrad). Small form.
5. *Zygospira cincinnatiensis* (James).
6. *Dalmanella emacerata* Hall.
7. *Crania scabiosa* Hall.
8. Crinoid stems (small).

No. 20. Shale, 7 inches.

No. 21. Limestone, 3 inches.

1 *Coeloclema concentricum* (James) (aa).
2. *Callapora oncalli-sigillaroides* (Nicholson). Large Stems possibly var. *Communis.*
3. *Bythopora arctipora* (Nicholson).
4. *Dekayella ulrichi* (Nicholson).
5. *Dalmanella emacerata* Hall (c).
6. *Zygospira modesta* Hall (rr).
7. *Plectorthis* sp. (rr).
8. *Acidaspis* fragments (c).
9. *Calymene callicephala* Green.

No. 22. Shale, 2 feet 6 inches.

No. 23. Crinoidal limestone, 7 inches.

1. *Coeloclema concentricum* (James) (r).
2. *Callopora oncalli-communis* (James).
3. *Bythopora arctipora* (Nicholson) (c).
4. *Batostoma implicatum* (Nicholson).
5. *Peronopora' vera* ?
6. *Dalmanella emacerata* Hall.
7. *Zygospira cincinnatiensis* Meek.
8. *Dalmanella multisecta* (Meek).
9. *Rafinesquina alternata* (Conrad).
   Fragment.
10. *Calymene callicephala* Green.
11. *Trinucleus concentricus* Eaton.
12. *Plumulites* sp.
13. Crinoid segments (aaa)
    This layer is probably the equivalent of the 120-foot level of Ulrich's section at Cincinnati.

No. 24. Shaly limestone, 5 feet 4 inches.

1. *Ceramoporella ohioensis* (Nicholson) (c).
2. ———— *distincta* Ulrich (r).

3. *Callopora onealli-communis* (James) (c).
4. *Bythopora arctipora* (Nicholson).
5. *Coeloclema* sp. (rr).
6. *Batostoma implicatum* (Nicholson) (rr).
7. *Peronopora decipiens* (Rominger) (r).
8. *Dekayella ulrichi* (Nicholson) ?
9. *Dalmanella emacerata* Hall (r).
10. *Zygospira cincinnatiensis* Meek (r)
11. ———————*modesta* Hall (c).
12. *Acidaspis ceralepta.* Meek.
13. ——————— fragment of another species.
14. *Plumulites* sp.
15. *Arthropora* sp.
16. *Calymene callicephala* Green.
17. *Asaphus* sp. fragments (c).
18. *Heterocrinus* segments.

No. 25. Dark crystalline limestone. Few identifiable fossils, 4 inches.
No. 26. Shale with thin layers of limestone, 6 feet 3 inches.
No. 27. Sandstone, 4 inches.
No. 28. Shale, 8 inches.
No. 29. Limestone with argillaceous material in spots, 7 inches.

1. *Coeloclema* fragment.
2. *Callopora* sp. probably *onealli-communis* (James).
3. *Atactoporella* sp. cf. *newportensis* or *typicalis.*
4. *Arthropora* sp.
5. *Dalamanella multisecta* (Meek) (a).
6. *Rafinesquina alternata* (Conrad). Very fine striæ.
7. *Zygospira modesta* Hall.
8. *Retzia* (?) *granulifera* Meek (rr).
9. *Anodontopsis* fragment.
10. *Acidaspis* fragments.
11. *Plumulites* sp.
12. Crinoids stems.

No. 30. Shale, 1 ft. 8 in.
No. 31. Limestone, 4 in.

1. *Coeloclema* sp.
2. *Ceramoporella ohioensis* (Nicholson).
3. *Peronopora vera.*
4. *Callopora onealli* var.
5. *Batostoma implicatum* (Nicholson).
6. *Aspidopora* sp.
7. *Heterotrypa cf. solitaria* Ulrich (rr).
8. *Escharopora acuminata* (James).
9. *Dalmanella multisecta* (Meek) (aaa).
10. *Rafinesquina alternata* (Conrad).
11. *Zygospira modesta* Hall.
12. *Trinucleus concentricus* Eaton (rr).

No. 32. Thin limestone and shale 2 ft. 4 in.

1. *Callopora onealli sigillarioides* Nicholson.
2. *Arthropora* [illegible] Nicholson.
3. *Dekayella ulrichi* Nicholson.
4. *Batostoma implicatum* Nicholson.
5. *Dalmanella multisecta* Meek.
6. *Zygospira modesta* Hall.
7. *Rafinesquina alternata* (Conrad) (r).

No. 33. Hard limestone. Fossils nearly all fragmentary. 10 in.

1. *Callopora* sp. small form.
2. *Arthropora* [illegible] Nicholson (c).
3. *Batostoma implicatum* Nicholson (r).
4. *Dalmanella multisecta* Meek (aaa).
5. *Zygospira cincinnatiensis* Meek.
6. *Calymene callicephala* Green.

No. 34. Shale 2 ft.

No. 35. Bryozoal limestone 3 ft.

1. *Dekayella ulrichi* (Nicholson) (a).
2. *Dalmanella multisecta* (Meek) (aaa).
3. *Asaphus* fragments (c).

No. 36. Shale and thin limestones, 2 ft. 6 in.

No. 37. Bryozoal limestone in thin layers, 2 feet, 6 inches.

1. *Dekayella ulrichi* (Nicholson) (aa).
2. *Coeloclema concentricum* (James) (a).
3. *Leptotrypa clavis* Ulrich (r).
4. *Callopora onealli* (James) var.
5. ——— ——— *communis* (James).
6. *Batostoma implicatum* (Nicholson). ?
7. *Zygospira cincinnatiensis* Meek. ?
8. *Zygospira modesta* Hall.
9. Crinoid segments (aa).

No. 38. Shale 5 ft.

No. 39. Crinoidal limestone, 8 in.

1. *Callopora onealli-communis* (James).
2. *Dekayella ulrichi* (Nicholson) (c).
3. Crinoid segments (aa).

No. 40. Shale 3 ft.

No. 41. Limestone, 2 in.

1. *Batostoma* sp.
2. *Dekayella ulrichi* (Nicholson) (c).
3. *Callopora onealli-communis* (James).
4. *Arthropora* [illegible] (Nicholson).
5. [illegible] fragments.
6. Crinoid segments.

No. 42. Shale 3 ft.

No. 43. Layers of calcareous sandstone, 6 in.

No. 44. Shale, 2 ft. 3 in.

No. 45. Thin layers of limestone, 5 ft.

1. *Coeloclema* sp.

2. *Peronopora decipiens* (Rominger).
3. *Callopora onealli-communis* (James).
4. *Bythopora arctipora* (Nicholson) (r).
5. *Ceramoporella ohioensis* (Nicholson).
6. *Dekayella ulrichi* (Nicholson).
7. *Arthropora* sp.
8. *Zygospira cincinnatiensis* Meek.
9. *Dalmanella multisecta* (Meek).
10. *Zygospira modesta* Hall.

No. 46. Shale 2 ft.
No. 47. Yellowish limetsone, 3 in.
No. 48. Shale, 1 ft.
No. 49. Coarse-grained limestone, 6 in.

1. *Coeloclema* sp.
2. *Arthropora* sp.
3. *Acidaspis* sp.
4. *Callopora oncalli* var.
5. *Dalmanella multisecta* (Meek) (aaa).
6. *Rafinesquina alternata* (Conrad) (c).

No. 50. Shale 2 ft. 8 in.
No. 51. Gray limestone, 3 in.

1. *Rafinesquina alternata* (Conrad) fragments (aa).
2. *Dekayella ulrichi* (Nicholson) (c).

No. 52. Shale, 10 in.
No. 53. Limestone, 3 in.

1. *Rafinesquina alternata* (Conrad) fragments (c).
2. *Dalmanella emacerata* Hall (r).
3. Crinoid segments (c).

No. 54. Shale, 6 in.
No. 55. Coarse-grained crystalline limestone, fragments of *Dalmanella multisecta* and *Rafinesquina alternata* abundant, 6 in
No. 56. Covered. Probably limestone, 25 ft.
No. 57. Compact limestone *Dalmanella multisecta* abundant, 7 in.
No. 58. Covered. 2 ft.
No. 59. Dark drab limestone, 4 in.

1. *Peronopora decipiens* (Rominger). Large form; very thick cell walls, numerous mesopores and acanthopores.
2. *Dekayella ulrichi* (Nicholson).
3. *Callopora onealli* var.
4. *Dalmanella multisecta* (Meek.)
5. *Rafinesquina alternata* (Conrad) fragments.
6. *Zygospira modesta* Hall.

No. 60. Covered, 8 ft., 8 in.
No. 61. Limestone, 1 ft., 2 in.

1. *Callopora* cf. *ramosa* or *dalci.*
2. *Dalmanella multisecta* (Meek) (aaa).

No. 62. Covered, 8 in.
No. 63. Bryozoal limestone, 6 in.

1. *Dekayella ulrichi* (Nicholson).
2. *Callopora* cf. *ramosa* (d'Orbigny).
3. *Zygospira modesta* Hall.
4. *Platystrophia biforata* (Schlotheim).
   Very small imperfect specimens, nearest to var. *dentata*.

Base of platystrophia zone.

No. 64. Covered, 6 ft.

No. 65. Thin-bedded bryozoal limestone, 8 ft.

1. *Callopora ramosa* (d'Orbigny). ?
2. *Dekayella ulrichi robusta* Foord.
3. *Platystrophia biforata* (Schlotheim). Small form, nearest to *dentata*.
4. *Herbertella occidentalis sinuata* Hall.

No. 66. Thicker-bedded, light gray limestone, containing fragments of *Rafinesquina alternata* in abundance. *Zygospira modesta* common, 1 foot.

No. 67. Covered, 1 foot 8 inches.

No. 68. Coarse grained limestone. *Rafinesquina alternata* abundant, 5 inches.

No. 69. Shale, 6 inches.

No. 70. Fine-grained limestone, containing *Zygospira modesta* Hall. 3 inches.

No. 71. Covered, 3 feet.

No. 72. Coarse-grained, crinoidal limestone. *Refinesquina alternata* common, 4 inches.

No. 73. Limestone, 1 foot 3 inches.

1. *Platystrophia biforata* (Schlothem). Small form with 17 plications (the normal number) on the ventral valve.
2. *Rafinesquina alternata* (Conrad). Very thin form.
3. *Escharopora pavonia* (d'Orbigny).
4. *Constellaria constellata* (Van Cleve). Large specimens.
5. *Batostoma* sp., probably new.

No. 74. Coarse-grained limestone, 3 to 8 inches.

No. 75. Covered, 6 inches.

No. 76. Compact limestone. *Rafinesquina* common, 4 inches.

No. 77. Covered, 3 feet 8 inches.

No. 78. Limestone with *Rafinesquina* and Bryozoa, 5 inches.

No. 79. Argillaceous-arenaceous, thin imestone. Some covered, 14 feet.

No. 80. Argillaceous-arenaceous limestone, 4 inches.

No. 81. Covered, 3 feet 3 inches.

No. 82. Yellow sandstone, 4 inches.

No. 83. Thin irregular limestone, 6 inches.

1. *Platystrophia biforata* (Schl.)
2. *Constellaria constellata* (Van Cleve).

No. 84. Thin-bedded limestone containing *Platystrophia biforata* (Schl.).

No. 85. Yellow argillaceous sandstone, 4 inches.

No. 86. Limestone with *Platystrophia* and *Hebertella sinuata*, 6 feet.

The remainder of the Platystrophia beds is, as stated above, from the exposures along the road a short distance from the upper exposures of the section just described. The zone which is here 40 to 50 feet thick is divided arbitrarily into eight equal sub-zones for the purposes of analysis of the faunas. These sub-zones are lettered *a* to *h* from the base up. Lithologically they vary but little, there being somewhat more sandy material in the lower layers and a greater percent. of argillaceous material further up in the section. All the layers are very thin and irregular and easily disintegrated constituting on the whole an extremely *shaly* limestone.

The faunas of these sub-zones are as follows:

Zone A:

1. *Homotrypa curvata* Ulrich (aa).
2. *Ceramoporella ohioensis* (Nicholson).
3. *Peronopora decipiens* (Rominger).
4. *Dekayia* sp.
5. *Heterotrypa inflecta* Ulrich.
6. *Dekayia aspera* E. & H.
7. *Callopora subplana* Ulrich.
8. *Callopora rugosa* (E. & H.). ?
9. *Bythopora* sp.
10. *Escharopora pavonia* (d'Orbigny).
11. *Escharopora falciformis* (Nicholson).
12. *Platystrophia biforata-lynx* (Eichwald).
13. *Platystrophia biforata-dentata* Meek.
14. *Rafinesquina alternata* (Con.).
15. *Plectorthis plicatella* Hall.
16. *Hebertella occidentalis-sinuata* Hall.
17. *Acidaspis* sp.
18. *Heterocrinus* sp.
19. *Cyclora minuta* Hall.

Zone B:

1. *Ceramoporella ohioensis* (Nicholson) (c).
2. *Bythopora delicatula* (Nicholson).
3. *Callopora rugosa* (E. & H.).
4. *Escharopora pavonia* (d'Orbigny).
5. *Monticulipora mammulata* (d'Orbigny).
6. *Escharopora falciformis* (Nicholson).
7. *Constellaria constellata* (Van Cleve) Dana.
8. *Petigopora asperula* Ulrich.
9. *Rafinesquina alternata* (Con.) typical (a).
10. *Zygospira modesta* Hall (a)
11. *Hebertella occidentalis-sinuata* Hall (c).
12. *Plectorthis plicatella* Hall.

13. *Platystrophia bioforata-lynx.* (Eichw.).
14. *Megambonia jamesi* Meek.
15. *Modiolopsis modiolaris* (Conrad) (c)
16. *Cyclonema bilix* (Conrad).
17. *Asaphus* sp.
18. Crinoid segments (c).
19. *Calymene callicephala* Green.

Zone C:

1. *Heterotrypa frondosa* (d'Orbigny).
2. *Nicholsonella vaupeli* (Ulrich) (c).
3. *Monticulipora molesta* Nicholson.
4. *Ceramoporella ohioensis* (Nicholson).
5. *Petigopora asperula* Ulrich.
6. *Escharopora falciformis* (Nicholson).
7. *Crania scabiosa* Hall.
8. *Zygospira modesta* Hall.
9. *Platystrophia biforata-lynx* (Eichw.).
10. *Platystrophia biforata laticosta* (Meek).
11. *Plectorthis plicatella* Hall.

Zone D:

1. *Amplexopora filiosa* (d'Orbigny).
2. *Heterotrypa frondosa* (d'Orbigny).
3. *Dekayia* sp.
4. *Callopora ramosa* (d'Orbigny).
5. *Escharopora falciformis* (Nicholson).
6. *Petigopora asperula* Ulrich.
7. *Ceramoporella* sp.
8. *Hebertella occidentalis-sinuata* Hall.
9. *Zygospira modesta* Hall.
10. *Rafinesquina alternata-fracta* (Meek).

Zone E:

1. *Callopora rugosa* (E. & H.).
2. *Petigopora asperula* Ulrich.
3. *Ceramoporella ohioensis* (Nicholson).
4. *Escharopora falciformis* (Nicholson).
5. *Heterotrypa frondosa* (d'Orbigny).
6. *Peronopora decipiens* var.
7. *Monticulipora molesta* Nicholson.
8. *Bythopora delicatula* (Nicholson).
9. *Bythopora gracilis* (Nicholson).
10. *Petigopora petechialis* (Nicholson).
11. *Atactoporella* sp.
12. *Proboscina auloporoides* (Nicholson).
13. *Rafinesquina alternata* (Con.) (c).
14. *Hebertella occidentalis-sinuata* Hall (a).
15. *Platystrophia biforata-lynx* (Eichw.).
16. *Zygospira modesta* Hall (aaa).
17. *Rafinesquina alternata-nasuta* (Con.).

18. *Cyclora minuta* Hall.
19. *Crania scabiosa* Hall.
20. *Conchiolites* sp.

Zone F:

1. *Callopora ramosa* (d'Orbigny) (c).
2. *Callopora rugosa* (E. & H.) (c).
3. *Bythopora delicatula* (Nicholson).
4. *Petigopora petechialis* (Nicholson).
5. *Ceramoporella ohioensis* (Nicholson).
6. *Monticulipora molesta* (Nicholson).
7. *Peronopora decipiens* (Rominger).
8. *Hebertella occidentalis-sinuata* Hall (aa).
9. *Platystrophia biforata-laticosta* (Meek) (aa).
10. *Platystrophia biforata-lynx* (Eichw.).
11. *Rafinesquina alternata-fracta* (Meek).
12. *Zygospira modesta* Hall.
13. *Plectorthis plicatella* Hall.
14. *Megambonia* sp.
15. *Calymene callicephala* Green.

Zone G:

1. *Callopora rugosa* (E. & H.).
2. *Bythopora* cf. *delicatula* (Nicholson).
3. *Platystrophia biforata-lynx* (Eichw.). (aa).
4. *Hebertella occidentalis-sinuata* Hall (aa).
5. *Rafinesquina alternata-ponderosa.** (aa).
6. *Plectorthis* sp. probably *plicatella.*
7. *Zygospira modesta* Hall.
8. *Crania scabiosa* Hall.

Zone H:

1. *Heterotrypa prolifica* Ulrich (c).
2. *Nicholsonella vaupeli* (Ulrich) (aa).
3. *Ceramoporella ohioensis* (Nicholson).
4. *Peronopora decipiens* (Rominger) (c).
5. *Monticulipora molesta* (Nicholson) (a).
6. *Bythopora gracilis* (Nicholson) (c).
7. *Homotrypa curvata* Ulrich. ?
8. *Heterotrypa frondosa* (d'Orbigny).
9. *Callopora rugosa* (E. & H.)
10. *Callopora ramosa* (d'Orbigny).
11. *Heterotrypa inflecta* Ulrich. ?
12. *Petigopora petechialis* (Nicholson).
13. *Bythopora delicatula* (Nicholson) (a).
14. *Petigopora asperula* Ulrich.
15. *Petigopora* sp., form with diaphragms ad large acanthopores.
16. *Spatiopora maculosa* Ulrich.

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*This name "used by collectors" has no technical standing, but might very well be adopted for the massive thick shelled *rafinesquinas* occurring so abundantly in the "lynx" beds.

17. *Proboscina auloporoides* (Nicholson).
18. *Platystrophia bifrata-lynx* (Eichw.).
19. *Platystrophia biforata-laticosta* (Meek).
20. *Hebertella occidetanlis-sinuata* Hall.
21. *Zygospira modesta* Hall.
22. *Rafinesquina alternata-ponderosa.*
23. *Rafinesquina alternata-nasuta.* (Con.).
24. *Crania scabiosa* Hall.
25. *Conchiolites* sp.
26. *Cyrtolites inornatus* Hall.
27. *Megambonia jamesi* Meek.

In addition to the species in the above lists, a miscellaneous collection from zones ***a*** to ***h***, inclusive, contains the following species:

1. *Heterotrypa paupera* (Ulrich)
2. *Dekayia magna* n. sp.
3. *Dekayella cystata* n sp.
4. *Amplexopora septosa* (Ulrich).
5. *Dekayia pelliculata* Ulrich.
6. *Callopora andrewsi* (Nicholson).
7. *Homotrypa obliqua* Ulrich.
8. *Batostoma varians* (James) ?
9. *Proboscina frondosa* (Nicholson).
10. *Trematis* sp.
11. *Beyrichia chambersi* ?
12. *Stomatopora inflata* (Hall).
13. *Plectorthis ella* Hall.
14. *Orthoceras* sp.

It is of interest to compare this section with that of Ulrich* at Cincinnati, especially since the latter is the type section for this part of the Upper Ordovician of the Ohio valley.

These two sections (Cincinnati and Vevay) may be tabulated as follows:

TABULATION OF ULRICH'S SECTION AT CINCINNATI.

430′		*Platystrophia lynx* and numerous bryozoa.	XII b.
	30′		
400′		*Callopora ramosa, C, rugosa, Bythopora gracilis, Heterotrypa inflecta, Peronopora compressa, Dekayia appressa, etc., Ambonychia jamesi, etc.*	
	15′		
385′		*Strophomena nasuta.*	
	15′		
370′		*Strophomena ponderosa.*	
	10′		
360′		*Atactoporella mundula, Constellaria constellata, Leptotrypa discoidea, Escharopora pavonia, Plectorthis plicatella. P. ella, Cyclonema bilix, Platystrophia crassa, Anodontopsis unionoides.*	XII a.
	50′		

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*Am. Geol., vol. i, pp. 305-315; vol. ii, pp. 39-44.

310′		*Strophomena planoconvexus.*	XII a.
	25′	Fossils rare. Worn specimens of *Orthis testudinaria.*	
285′		*Homotrypa curvata, Dekayia aspera, Heterotrypa frondosa.*	
	20′		
265′		*Callopora dalei, C. subplana, Peronopora vera.*	
	5′		
260′		Reappearance of *Dekayella* fauna.	
	80′		
180′		*Callopora sigillaroidea* (large form), *Constellaria constellata* var. *prominens.*	XI b.
	60′	Zone of *Dekayella uirichi, D. Obscura, Batostoma jamesi, B. implicatum, Callopora sigillaroidea, Cœloclema alternatum, C. concentricum, Dallmanella multisecta, etc.*	
120′		*Trinucleus concentricus* and *T. bellulus.*	
	40′		
80′			
	20′	Nearly barren.	
60′		Zone of *Leptobalus insignis, Triarthrus, becki, etc.*	
	10′		
50′			XI a.
	50′		
0		Low water level of Ohio river at Cincinnati.	

TABULATION OF SECTION AT VEVAY.

357′		*Platystrophia lynx* (aa) (zone *h*).	Zone of *Platystrophia biforata.*	Zones XII *a* and XII *b* of Ulrich.
		P. laticosta, etc.		
	55′	Zone *a* to *h*. *Monticulipora molesta, Heterotrypa frondosa, H. prolifica* (near top). *H. inflecta, Callopora rugosa, C. ramosa, Nicholsonella vaupeli, Rafinesquina fracta. R. nasuta, R. ponderosa Hebertella sinuata, Plectorthis plicatella, Platystrophia laticosta, etc.*		
302′		*Callopora subplana, Homotrypa curvata, Dekayia aspera* (zone *a*).		
	12′			
290′		*Platystrophia bilorata, Constellaria constellata.*		
	30′			
260		*Constellaria constellata, Escharopora pavonia, Platystrophia laticosta,* (No. 73.)		
	20′			
240		*Platystrophia biforta* (small), *Dekayella ulrichi* (No. 63), lowest specimens of *Platystrophia.*		
	44′	*Rafinesquina alternata* very abundant, *Dalmanella multisecta* abundant.	Zone of *Dalmanella multisecta.*	XI *b* of Ulrich.
196′				
	6′	*Callopora onealli-communis* abundant.		
190′				
	46′	Zone of *Dekayella ulrichi*, etc., *Dalmanella multisecta, etc.*, (Nos. 3 to 49).		
		Trinucleus concentricus (No. 23).		
144′				
	44′			
126′		*Dekayella ulrichi, Batostoma implicatum, Callopora sigillaroides, Cœloclema alternatum, etc.* (No. 11).		
	20′			

101′	....	Base of exposed section. *Dalmanella multisecta*. *Plectambonites sericeus*. (No 3).	Lower *Plectambonites sericeus* Zone. XI *a* of Ulrich in part.
	101′		
0	....	Level of Ohio river at Vevay.	

The correspondences between these two sections are too apparent to need further emphasis. Numbers 3 to 49 of the Vevay section have an aggregate thickness of approximately 96 feet. The same zones in the Cincinnati section have an aggregate thickness of about 100 feet. *Trinucleus concentricus* comes in at almost exactly the same level in both sections. Number 63 of the Vevay section is probably to be correlated with the 260 foot level of the Cincinnati section and number 45 with the 180 foot level of the latter. Number 73 is *not* the equivalent of Ulrich's 180 foot level. *Constellaria constellata* ranges through a considerable thickness of rocks.

Numbers *a* to *h* of the Vevay section seem to be equivalent to all above the 285 foot level of the Cincinnati section; though the unexposed portions of the Vevay section may conceal a zone of *Homotrypa curvata* between numbers 55 and 83. Certain it is that this well characterized species occurs abundantly in zone *a,* though not above it. If it is true that these *Homotrypa* zones are equivalent, then the beds XII *a* of Ulrich's section are to a large degree suppressed in the Vevay section.

It remains to discuss certain peculiarities in the range of several species.

Callopora onealli sigillaroides occurs in the lowest layers as a very small form and increases in size but without alteration of internal characters as higher layers are reached passing apparently into the variety *communis* of James, a form occurring in large masses and prodigious numbers in some of the higher zones.

Dekayella ulrichi seems to experience a similar progressive increase in size the variety *robusta* occurring in beds well up in the series.

Dalmanella multisecta occurs in nearly every limestone layer up to the base of the *Platystrophia* zone; and numbers 3 to 61 inclusive may with great propriety be called the *Dalmanella multisecta* zone. Where this species occurs abundantly the young stages can usually be obtained. Specimens in the writer's collection, of a width of less than 1 mm., and even so small as 0.5 mm. are not infrequent. These together with similar developmental material from the zone of *Dalmanella meeki* higher up in the series await description in another place.

Platystrophia biforata and its varieties has been discussed in detail in a paper by Mr. Mauck and the writer on a quantitative study of variation in this species. There could scarcely be a better locality than Vevay for the collection of adequate series of this interesting species, and especially of the so-called variety *lynx*.

Rafinisquina alternata also exhibits minute variations from zone to zone culminating in the form *ponderosa* of the *lynx* beds. This protean species would well repay quantitative study and here again Vevay would readily furnish suitable material.

DESCRIPTION OF NEW SPECIES.

Dekayia magna, n. sp.

PLATE XXXIV, FIGS. 1 TO 6.

In form and general appearance this species closely resembles *D. aspera* E. & H. The zoarium consists of irregular flattened branches (as in the Lawrenceburg specimen) or more frequently of robust frequently branching masses (as in the Vevay specimen) of a diameter of 40 mm. or more. Spines can occasionally be detected upon the surface.

Tangental sections show that the cell walls are thin with usually a well defined median lamina. Acanthopores few, *small*. Diaphragms extremely few; occasionally one or two near the surface.

Observation: This form might be considered as identical with *D. aspera* but for the small size and less frequency of the acanthopores.

Locality: Vevay and Lawrenceburg, Indiana, in the *Platystrophia laticosta* zone.

Dekayella cystata, n. sp.

PLATE XXXV, FIGS. 1 TO 6A.

Zoarium consisting of flattened branches, at times 30 mm. or more in width. Surface covered with small conical monticules, about three in the space of 5 or 6 mm. Cells 0.2 mm. to

0.15 mm. in diameter. The monticules are composed of groups of cells larger than the average interspersed with a greater or less number of very minute cells (mespores). The latter are practically confined to the regions of the monticules.

Tangental sections reveal the characteristic cell structures of the genus, with the large and small sets of acanthopores.

Longitudinal sections show numerous diaphragms about one-half cell diameter apart in the large cells and much more numerous in the mesopores. A peculiarly characteristic thing is the presence of an occasional cystiphragm, especially near the surface.

Observation: This species might easily be mistaken for *Heterotrypa subpulchella* from which it differs in the two sets of acanthopores and the presence of curved diaphragms.

Locality: Veray in the *Platystrophia lynx* beds.

Amplexopora multispinosa, n. sp.

PLATE XXXIV, FIGS. 7 to 10.

Zoarium consisting of frequently branching cylindrical or sub-cylindrical stems of an average diameter of from 8 to 10 mm. Surface with inconspicuous maculæ. Cells of average size about 0.2 mm. in diameter.

In longitudinal sections the cells are seen to be thin walled in the axial region and without diaphragms. They bend somewhat abruptly toward the surface, becoming greatly thickened and at the same time developing in the passage from the immature to the mature region a considerable number of diaphragms many of which are curved or even coalesce giving the false appearance of cystiphragms. Near the surface, diaphragms are again lacking.

In tangental sections, cutting the mature region, the cell-walls are thick, with very clearly defined true walls thickly interspersed with small acanthopores and covered by a copious deposit of secondary schlerenchyma.

Localiqy: Associated with *Callopora communis* in the upper *Dalmanella multisecta* beds, at Vevay and Milton, Indiana.

Eridotrypa vevayensis, n. sp.

PLATE XXXV, FIGS. 7 AND 8.

The zoarium of this species cannot be described owing to the fact that all the specimens seen were fragments imbedded in the limestone matrix. It is however of small size.

Internally the species is seen in tangental and longitudinal sections to possess a structure closely similar to that of *E. briareus* (Nicholson sp.), from which it differs in the presence in fair abundance of mesopores and in the general obliquity of the diaphragms. The latter are more numerous in the mesopores.

Locality: Vevay, Indiana, in the ***Dalmanella multisecta*** zone, associated with ***Dekayella obscura*** and ***Callopora onealli***: Also at a similar level in the Kentucky bank of the Ohio near Lawrenceburg, Indiana.

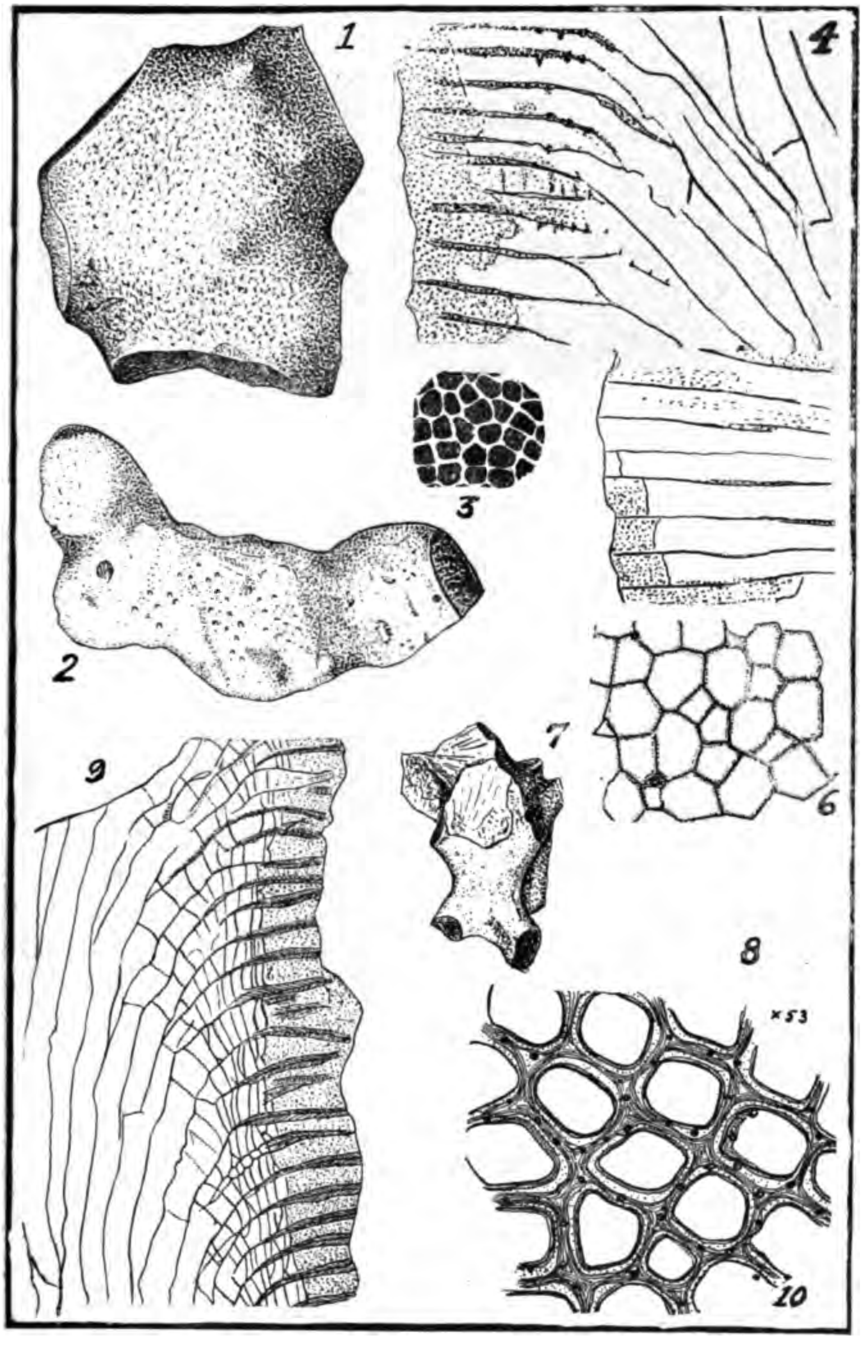
Yale University, Oct., 1901.

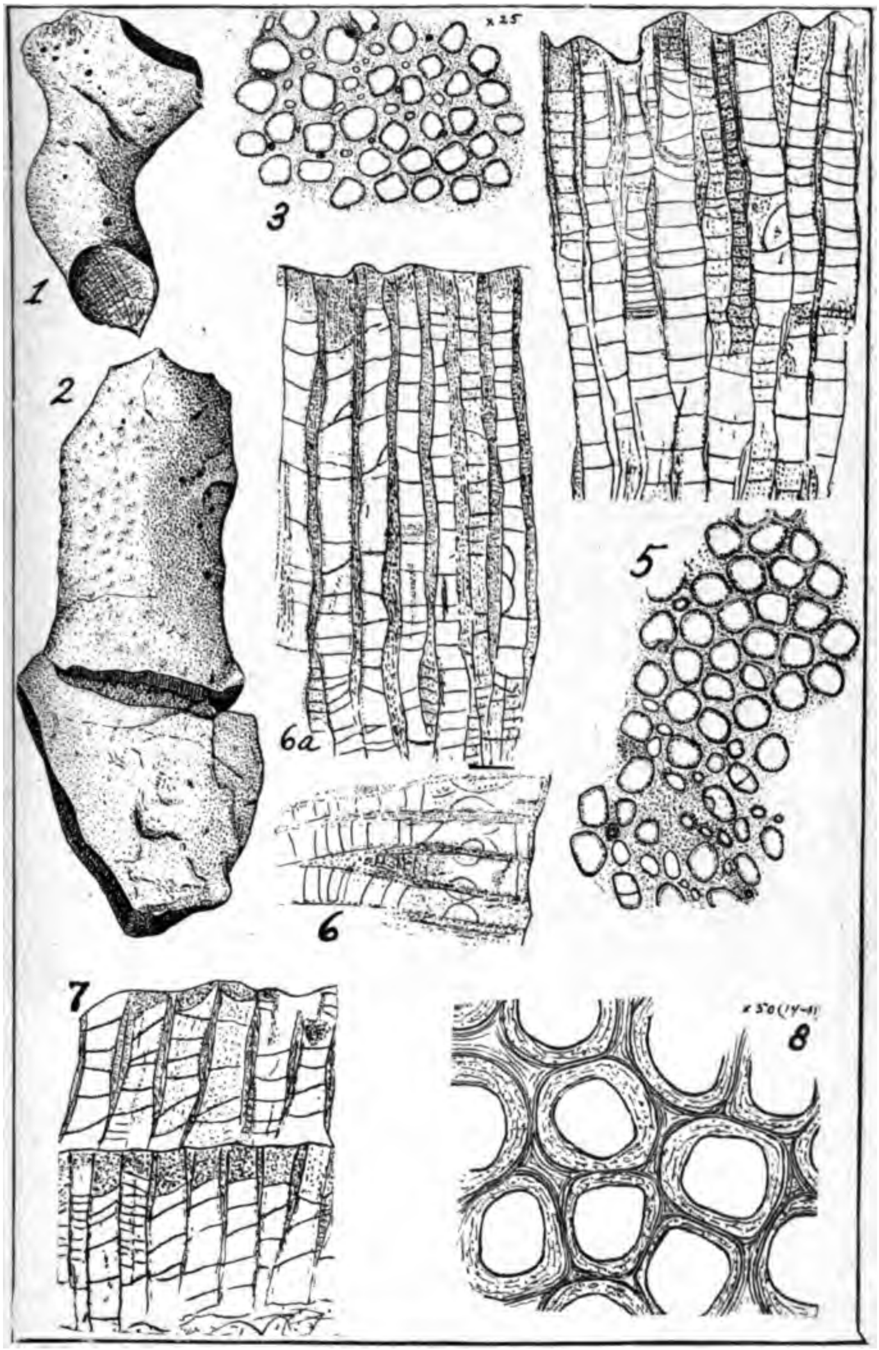
Explanation of plate xxxiv.

Figs. 1-6, *Dekayia magna*, n. sp. ....p. 32
  Fig. 1. Fragment of a zoarium from Vevay, natural size.
  Fig. 2. Fragment from Lawrenceburg, natural size.
  Fig. 3. Surface of Lawrenceburg specimen ×18.
  Fig. 4. Longitudinal section of same.
  Fig. 5. Longitudinal section of a Vevay specimen.
  Fig. 6. Tangental section of 2.
Figs. 7-10, *Amplexopora multipinosa* n. sp. ....p. 34
  Fig. 7. Fragment of zoarium showing bases of four branches.
  Fig. 8. Fragment from which the sections represented in Figs. 9 and 10 were cut.
  Fig. 9. Longitudinal section ×18.
  Fig. 10. Tangental section near surface ×53. Specimens 7-10 from Milton, Indiana.

Explanation of plate xxxv.

Figs. 1-6a, *Dekayella cystata* n. sp. ....p. 33
  Figs. 1 and 2. Views of portions of two zoaria, natural size, showing general shape of zoarium and character of monticules.
  Fig. 3. Tangental section near surface of 2.
  Fig. 4. Longitudinal section of 2.
  Fig. 5. Tangental section of 1.
  Figs. 6 and 6a. Longitudinal sections of 1, showing cystiphragms. Locality—Vevay, Platystrophia zone.
Figs. 7-8, *Eridotrypa vevayensis* n. sp. ....p. 35
  Fig. 7. Longitudinal section showing two mature zones.
  Fig. 8. Tangental section from same individual ×50 showing thick walls, mesopores and absence of acanthopores. Locality.—Vevay (No. 15).


×53


x 25
6a
x 50 (14-11)

THE VEVAY SECTION (NUMBERS REFER TO ZONES)

37	39	41	45	49	51	53	55	59	61	63	65	73	83	a	b	c	d	e	f	g	h
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x	....	....	x	....	....	....	....	x	....	x	....	....	..	..	a	x	..	aa	aa	x	x
?	....	....	x	....	....	....	....	....	....	....	....	....	..	..	..	..	..	..	..	..	..

TABLE SHOWING THE DISTRIBUTION OF SPECIES IN

	3	5	7	9	11	13	15	17	19	21	23	24	29	31
73 *Platystrophia biforata* (Schlotheim)														
74 *Platystrophia biforata denata* (Pander)														
75 *Platystrophia biforata laticosta* (Meek)														
76 *Platystrophia biforata lynx* (Eichwald)														
77 *Hebertella occidentalis sinuata* Hall														
78 *Plectorthis plicatella* Hall														
79 *Plectorthis ella*														
80 *Plectorthis* sp.										x				
81 *Retzia granulifera* (Meek)													?	
82 *Trematis* sp.														
TRILOBITA.														
83 *Calymene callicephala* Green					x			x		x	x	x		
84 *Proetus* sp. indt.					x									
85 *Acidaspis ceralepta* Meek												x	x	
86 *Acidaspis* sp.												x	x	
87 *Acidaspis* sp.										x		x		
88 *Trinucleus concentricus* Eaton											x		x	
CIRRIPEDIA.														
89 *Plumulites* sp.											x			x
PELECYPODA.														
90 *Anodontopsis* sp													x	
91 *Megambonia jamesi* Meek														
GASTROPODA.														
92 *Cyclora minuta* Hall														
93 *Cyrtolites inornatus* Hall				x										
94 *Cyclonema bilix* (Conrad)														

THE CLEVELAND WATER SUPPLY TUNNEL.

By S. J. PIERCE, Cleveland, Ohio.

Since 1896, the city of Cleveland, Ohio, has been engaged in constructing a new water-works tunnel under lake Erie. for the purpose of securing a sufficient and better supply of water. During the construction of this tunnel the geological features have been noted from time to time. These observations, with the records of an older tunnel, are here presented to the AMERICAN GEOLOGIST. The object of this paper is to present the observations made and results shown, without in any way touching on theoretical ground.

THE TUNNEL.

The new tunnel commences on the east side of the river mouth about two and one half miles east of the Public Square, and extends in a northwest direction under the lake. Its length, from the shore to the permanent steel intake crib is 26,000 feet,—a trifle short of five miles.

The bottom of the tunnel is 100 feet below the lake level at the shore, and 110 feet below at the intake crib. This gives a slope of two feet per mile to lakeward. The depth

SECTION (NUMBERS REFER TO ZONES.)—*Continued.*

37	39	41	45	49	51	53	55	59	61	63	65	73	83	a	b	c	d	e	f	g	h
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of water at the shore is thirty-seven feet; and at the lake end, fifty-seven feet. The tunnel is nine feet in diameter in the clear, and is lined throughout with three courses of brick. Two temporary cribs were sunk in the lake over the line of the tunnel to facilitate the construction, the work progressing in each direction from the cribs and from the shore.

The construction of this tunnel was begun in October, 1896, and it is expected to be completed about a year from the present time. Its capacity will be 175,000,000 gallons in twenty-four hours.

THE GEOLOGICAL FEATURES.

The entire length of the tunnel has been in a sedimentary deposit, of very fine stratified blue clay. This seems to be of similar formation to the clay forming the bluffs along lake Erie, and which has been named by Newberry the Erie blue clay. In the workings of the tunnel this clay has been found to be stratified throughout by innumerable very thin strata of dry quicksand. While the entire deposit is built up of alternating strata of quicksand and clay, yet there are some strata more distinctly defined than others. The strata of clay vary in thickness; but what appear to be the best developed strata of clay range from about three-fourths of an inch to one and one-half inches in thickness, or even more. This, however, is only the general appearance; for a closer observation shows that these strata, and, in fact, the entire body of clay, may be subdivided by bands of quicksand as mentioned above.

Some of the deposits of quicksand are plainly observable, as those which separate the clay into layers of about one inch in thickness. The thin seams of quicksand separating the clay vary, but they seldom measure three-sixteenths of an inch in thickness. The general thickness of the quicksand is from a sixty-fourth of an inch, or less, to an eighth of an inch. Often the seams are so fine that they are not visible to the unaided eye. But taking the clay and pulling it at right angles to the line of stratification will divide it perfectly along the strata as if cut with a knife. At times sheets of clay from one to several inches in thickness fall from the roof of the tunnel like broad strips of rubber belting. The clay is very tenacious and can be peeled off the roof by the yard in almost any desired thickness, like the bark from a tree.

The strata are horizontal in the greater part of the workings, but places are found where they have been more or less disturbed by wave action. Some places show cross bedding, and others are much folded.

In no place has anything but stratified material been found, and that of the finest composition. At a few places fine sand has been found; but they appear mainly as pockets. The amount of quicksand which enters into the composition of the body of the clay varies somewhat from point to point; but where more than the normal amount is present it becomes what is termed "short," i. e. it breaks readily and is not easily supported by the compressed air.

It may be stated here that all work is done under a pressure of about two atmospheres. This supports the clay in the roof and keeps it from coming in at the face, besides keeping in check the gas which is found more or less throughout the clay.

The following analyses were made by Prof. A. W. Smith, of the Case School of Applied Sciences, Cleveland. No. 1 is quicksand, 7,900 feet from the shore. No. 2 is clay from the same place. No. 3 is clay, 19,600 feet from the shore.

		No. 1.	No. 2.	No. 3.
Combined water	H_2O	6.40	7.60	7.57
Total silica	SiO_2	62.50	60.60	53.53
Quartz or free silica		29.3	....	32.5
Alumina	Al_2O_3	11.30	16.20	23.76
Iron oxide	Fe_2O_3	6.52	2.60	2.15
Calcium oxide	CaO	7.25	5.05	7.16
Magnesium oxide	MgO	1.75	3.00	3.06
Potassium oxide	K_2O	2.20	2.20	.24
Sodium oxide	Na_2O	1.30	1.01	.46
Sulphuric anhydride	SO_3	.27	.72	1.63
Carbonic "	CO_2	.15	.32	.64
Titanium oxide	TiO_2	.60	.27	.20
		100.24	99.57	100.40

GLACIAL MATERIAL.

Quite a number of fragments of rock, both glaciated and unglaciated, have been found. None of these have exceeded eighteen inches in longest diameter, the majority being much smaller. None have been much less than two inches in diameter. Many were more or less rounded and smoothed by the action of water; some were very roughly angular, showing no glacial or water action at all; others showed very perfect and deep striæ on two or more sides.

The distribution of the rock fragments has been quite uniform, but somewhat more frequent near the shore than a few miles out. At no place could they be said to be plentiful. They varied much in material; many were syenites, and, with the exceptions of the shales and sandstones, they were of foreign origin. Though fine gravel or coarse sand was found in a few places, it is a noticeable fact that the rock fragments and the gravel (or more properly sand) did not grade into each other.

AN OLD RIVER CHANNEL.

The records of the Cleveland Water Works Department in Volume 16, contain some interesting information in regard to the two nearly parallel tunnels, each about one mile and a quarter in length, which are now in use, completed respectively in 1874 and 1890, situated close west to the Cuyahoga river mouth. In the construction of one of these tunnels, what was apparently the channel of the old Cuyahoga was found at a depth of about eighty-five feet below the surface of the lake.

A description of the preglacial valley of the Cuyahoga river was given in the AMERICAN GEOLOGIST, September, 1897. By way of explanation to the following, it may be stated that the records of numerous wells drilled in Cleveland and vicinity, show a deep V-shaped preglacial valley emptying into lake Erie. The deepest part of this old valley, as determined by its rock walls and bottom, is about three and a half or four miles east of the present mouth of the river, and has a depth of about 450 feet below the lake level. The east side of this old valley is quite abrupt. From the deepest part its west side rises gradually and outcrops a short distance beyond the mouth of the river. This preglacial valley has been traced back from the lake front about nine miles. It is now entirely filled with a sedimentary deposit, over and through which the present river flows. It is probably in this deposit which extends under lake Erie that the old river course was discovered. This old channel, which is described below, is over eighty feet below the present lake level.

The best idea is obtained from a part of the report of Volume 16, as follows:

"When the test holes were bored in the clay along the line of the tunnel, care was taken to sink them far enough away from the proposed line to avoid any danger of running the tunnel near them, in case the crib could not be located upon the spot designated. The outer boring was made about 300 feet westerly from the crib, and the clay brought up was of the best quality for tunneling in; and that under the crib is believed to be only a pocket or narrow valley in the original deposit, subsequently filled by clay sediment, and not yet solidified, though having precisely the same appearance as the harder clay when dried. In building the shore end of the tunnel two such deposits were passed through, the soft deposits first appearing at the top of the excavation, and inclining at such an angle that after digging but a few feet the whole excavation was in this soft clay; this was continued (with the exception of a narrow ridge or island of hard clay reaching to about the center of the tunnel) for a distance of about 300 feet when the hard clay was again met with at the bottom of the excavation, and leaving the soft clay at an angle inclined in an opposite direction from that in which it was entered. The second deposit of this character was entered and left the same as the first, the second being a little longer than the first.

"The horizontal direction of the first deposit was from southeast to northwest, and that of the second deposit was from southwest to northeast, the sides forming what appear to have been the banks of an old water course. The clay under the crib being the same as found nearer shore in this valley leads to the belief that it rests on the deposit filling this old channel."

The soft material on which this crib rests is well shown in the fact that during a storm shortly after it was placed, it sank eleven feet in one night, and has settled over thirteen feet in all.

The clay through which both the old tunnels were excavated is reported to have been unstratified, except at the localities noted as parts of an old river channel. But the new tunnel passes all the way, nearly five miles, in stratified clay; and the shaft at the new intake crib was wholly in stratified clay from the lake bed to the bottom of the tunnel, fifty-three feet. The old tunnels are at the upper part of the western ascending slope from the submerged continuation of the preglacial and drift-filled Cuyahoga valley; and the new tunnel lies nearly at the center, though not the deepest part, of that valley.

EDITORIAL COMMENT.

FUNDAMENTAL CHANGES IN THE ARCHEAN AND ALGONKIAN, AS UNDERSTOOD BY PROF. VAN HISE OF THE UNITED STATES GEOLOGICAL SURVEY.

The following extracts are from the twenty-first annual report of the United States Geological Survey, part 3, pp. 317 and 402, 1901. Their bearing on the differences that exist concerning these rocks between the United States and the Minnesota surveys is apparent to those who have been familiar with the course of investigation of the geology of the Lake Superior region.

"The foregoing papers[*] render it unnecessary for me here to take up the general stratigraphy of the lake Superior region. However, our work north of lake Superior, in northeastern Minnesota and Canada, has upon two points modified our published conclusions as to succession and correlation. Those who compare this paper with other papers will note two important modifications. First, the Archean has heretofore been supposed to be composed wholly of igneous rocks, no sediments having been recognized in this divsion of the pre-Cambrian. The north-shore work, however, makes it very probable that certain of the sedimentary iron-bearing formations must be included in the Archean. As examples of such are the productive iron formations of the Vermilion and Michipicoten districts. This modification is important from a theoretical point of view, since it will make changes necessary in my general definition of the Archean and of the Algonkian. The Algonkian has been defined to include all pre-Cambrian sedimentary rocks. The Archean has been defined to include all pre-Algonkian rocks, and has been supposed to contain igneous rocks only. These definitions must be modified so as to include in the Algonkian all pre-Cambrian series which are dominantly of sedimentary origin or equivalent in age with those which are dominantly of sedimentary origin. The Archean must be defined to comprise the rocks older than the Algonkian which are dominantly of igneous origin, but which may include subordinate amounts of sediments. Recent work in northwestern Europe, and especially in Scotland, Scandinavia and Finland, where the ancient rocks are best exposed in Europe, shows that these modifications in the definitions of the Archean and Algonkian are also there applicable. The changes are quite in line with what might be expected, for in recent years no one feature in geological advance has been more significant that the sweeping away of sharp dividing lines between the various periods.

"Second, the iron-bearing formations of the Vermilion and similar districts I have heretofore regarded as Lower Huronian. In placing these formations in the Archean I recognize three series in which productive ore formations are found, the Upper Huronian, the Lower Huronian, and the Archean.

"The evidence upon which these modifications of my opinion concerning the Lake Superior stratigraphy are based cannot be here presented in detail. It will be fully given in a monograph on the Vermilion district to be published later. In general it may, however, be stated that our work in the Vermilion district of Minnesota and on the Canadian side of the international boundary has convinced us that bands of sedimentary iron-bearing formation are interstratified with the upper part of the oldest series of the Lake Superior region, composed of greenstones, greenstone schists and tuffs, although the thick productive beds of the Archean appear to rest upon the greenstones and greenstone schists."

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[*] A list of the publications of the United States Geological Survey respecting the formations and iron ores of lake Superior. [N. H. W.]

The succession of formations above given differs from that which I supposed would be found before the Vermilion district was studied in detail. I had supposed that the Animikie series was equivalent to the series here placed in the Lower Huronian. When the relations were first studied in the field by the members of the United States Geological Survey, Mr. Clements and Mr. Leith thought that the relations of the two series was those of unconformity. When I reached the field later and saw the same facts, I was inclined to believe that the phenomena were more likely to be explained by overlap. However, in the season of 1900, when Mr. Leith began studies upon the Mesabi district, he showed that the Mesabi series, which is undoubtedly the equivalent of the Animikie series, with gentle inclination rests unconformably upon vertical slates and conglomerates equivalent to the Knife Lake slates and Ogishke conglomerates. I have therefore no doubt that the correct interpretation of the phenomena in the Vermilion district is that of unconformity between the Animikie series and the Lower Huronian series.

"Before closely studying the Vermilion district in the field, supposing the two series to be the same, I also thought it probable that the iron-bearing formation of the Vermilion would turn out to be the equivalent of the Lower Huronian iron-bearing formation of the south shore of lake Superior in the Marquette district. But very careful work by Messrs. Clements, Merriam, Leith and myself has failed to discover any great structural break between the Soudan formation and the great Ely greenstone formation which is undoubtedly Archean. Therefore we now recognize an iron-bearing formation in the Archean. Here, as elsewhere in the Lake Superior region; there is great unconformity between the basal Archean complex, consisting mainly of granites, gneisses, greenstone schists, and greenstones, but containing subordinate amounts of sediments, and the sedimentary series of the Lower Huronian."

These modifications, barring differences of nomenclature, constitute an important step toward concordance respecting the general geological structure of northeastern Minnesota, between the United States and the Minnesota surveys. The study and interpretation of the geology of the Lake Superior region, and of the iron ores found on both sides of that great depression, is a very arduous and complicated undertaking. There is no reason to expect complete agreement between the observers who work on the different parts of the problem, even when they examine the same facts at distant points. Northern Minnesota is a district in which the oldest rocks can be studied with exceptional ease. The classification which may be ultimately evolved when they are fully worked up, in connection with the adjacent portions of Canada, will be likely to stand for many years as the American standard for those rocks. There is no doubt that numerous errors will be committed in the first announcements by the various surveys, and by the partial investigators, necessitating modifications when they shall be discovered. It is to be hoped that all will be as ready to admit changes in their interpretations when convinced of error, as is Prof. Van Hise. At a future occasion the writer will perhaps call attention more in detail to the effect of these modifications.

N. H. W.

REVIEW OF RECENT GEOLOGICAL LITERATURE.

A Treatise on Zoology. Edited by E. RAY LANKESTER. *Part III. The Echinoderma,* by F. A. BATHER, assisted by J. W. GREGORY and E. S. GOODRICH. (A. and C. Black, London, 1900. pp. i-viii, 1-344.)

The student of zoology, if he wishes an elementary text-book, finds as great difficulty in making his selection as he does in buying a new bicycle or typewriter. Apparently the more advanced student will not be thus hampered by an embarrassment of riches, for it is doubtful whether any work aims as high and attains as much as the volume under review.

The average worker who has added somewhat to his primary zoological training finds it a dreary and often fruitless performance to extract the new facts of science or the present state of knowledge on any particular topic from the almost endless collection of "elementary" text-books, no matter how valuable they may be in fulfilling their true function. It is almost equally tiresome to sift out the same information from the great mass of technical papers on particular things. The present volume supplies in a large degree this deficiency for the Echinoderma, and is a most welcome addition to general zoological literature. The entire series is planned to include ten parts, of which this is the third. Each of the larger groups of animals is to be described by a separate author after a definite model, in order to secure uniformity both in scope and method.

The general systematic survey of the phylum Echinoderma, with its seven classes, is quite full and comprehensive and includes the main facts of ontogeny, phylogeny, anatomy, and classification. The orders and families are all clearly defined and most of the prominent genera are reviewed and mentioned. One of the striking features of this volume is the fullness with which the fossil forms are treated, thus according them their true value in any general treatise on echinoderm morphogeny. Instead of the starfishes and sea-urchins constituting the entire program, or "whole show," as they do in the minds of the average student and in half of the text-books, here they form but the last two of the seven classes recognized, and the length of their discussion is in proper proportion. It is sincerely to be hoped that similar true values will be given among other classes, whether extinct or not.

The phylum Echinoderma comprises two divisions or grades, the Pelmatozoa and the Eleutherozoa. In the first are the classes Cystidea, Blastoidea, Crinoidea, and Edrioasteroidea. In the second grade are the Holothuroidea, Stelleroidea, and Echinoidea. This arrangement shows the unequal value of the classes and does not express their phylogenetic relations. The latter probably would be more truly represented, according to Bather, by placing a primitive class, Amphoridea, at the base and deducing from it several lines of descent; namely, Edrioasteroidea, Anomalocystida, Aporita, Rhombifera, and Diploporita. From the Edrioasteroid line, it is supposed, there sprang first Holothurians, then Stelleroidea, then Echinoidea. The blastoids are included in the Diploporite line, and from them as a fresh development with a new lease of life arose the important class Crinoidea, whose discussion occupies, as is wholly proper, nearly one-third of the present volume.

The class Stelleroidea comprises the Asteroidea and Ophiuroidea, generally considered as quite distinct. Some recent genera, however, and many of the fossil forms show that no clear line of separation can be drawn, though the names are still retained for simple convenience.

The usual primary subdivisions of the Echinoidea into two subclasses, the Palæechinoidea and Euechinoidea, have been abandoned and the older divisions Regularia and Irregularia adopted. The primitive ancestral Echinoid is unknown, though it is evident that the first forms were small sac-like bodies, with the mouth and arms at opposite poles and the muscular body supported by a series of angular plates, of which five pairs were perforated by pores. The thickening of the plates and the consequent loss of flexibility is believed to explain the reduction in the number of vertical rows taking place in the passage from paleozoic to neozoic genera. C. E. B.

Recently Discovered Extinct Vertebrates from Egypt. By CHAS W. ANDREWS, D. Sc., F. G. S., of the British Museum. (The Geological Magazine, September and October, 1901.)

Northern Africa has long been regarded with peculiar interest, for the reason that the geographical distribution and stage of development of many Recent and Cænozoic vertebrates, gave evidence that Africa was a centre in which they evolved and from which they migrated. Through the courtesy of the Egyptian Survey, Mr. Andrews has visited the Libyan desert, with eminently satisfactory results.

The formations extend from Eocene through Pliocene, and contain a large number of fossiliferous horizons. Mammals, reptiles, turtles, crocodiles, and fishes were found in large numbers.

Among the most interesting of these discoveries is a (presumably) Lower Oligocene proboscidian, for which Mr. Andrews proposes the name *Palaeomastodon beadnelli.* The Proboscidia are a most extraordinary group in point of specialization, their tooth and foot structure being unique in the animal kingdom. The Lower Miocene of Europe has long been noteworthy for the first appearance of the group in a highly specialized form, *Mastodon angustidens.* It is of great interest to find that *Palaeomastodon* presents a tooth structure of much greater simplicity and more generalized type than this most primitive previously known proboscidian. Other members of the group were found, and we may henceforth look upon northern Africa as their centre of radiation.

The evolution of the African fauna is entirely independent, the animals differing from those found in deposits of the same age in Europe. The existence of a large and long isolated land area to the south is thus indicated. I. H. O.

Ueber die Entwickelung der Silurischen Sedimente in Böhem und in Sudwesten Europas, von Fritz Frech, mit 6 fig. (Neuen Jahrbuch für Mineralogie etc., Jahrg. 1899, Bd. ii.)

This article collates from various sources (the works of Barrande Bergeron Barrios Brögger, etc.) information gathered as to the changes of the Silurian and Cambrian sediments in various parts of western Europe.

The author describes a continental area extending from north of Bohemia through France and Spain where no upper Cambrian sediments have been found as separating two marine areas in the N. W. of and the S. E. of Europe respectively. Over this island by transgression in Lower Ordovician time the sea gradually spread introducing the great Asaphi and eventually the Calymmenidæ into areas which previously had only coarse sediments, conglomerates, grauwackes and coarse sandstones. The depression went on until abysmal forms like the graptolites and the radiolarians appeared and spread over wide areas, especially in England, France, and the eastern Alps as well as the northwestern or Scandinavian sea of that period. The article discusses and approves of Dr. Brögger's determinations of the equivalent of the Ceratopyge fauna (Tremadac) with his interpretation of the genera mentioned in the works of Barrois, Bergeron, Salter and others who have studied the faunas of this period of Palæozoic time.

G. F. M.

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CORRESPONDENCE.

When was the Mississippi River Valley Formed? The age of the Mississippi river seems to be sometimes a question. On the flood plain and along the bluffs at Clinton and Davenport, Iowa, and at numerous other places are deposits of the Carboniferous like the under clay of the Illinois coal fields, evidently remnants of the lower coal formation which was deposited and then swept away by the river when an elevation occurred. The town plot of Clinton is filled with these pits, which are uncovered in making foundations. Some deep pits were excavated in making the foundations for the Rock Island government works some years ago.

Prof Hall in the first volume of Iowa geological reports noticed this, and gave some figures. One was shown in a quarry at Rock

Island, opposite Davenport, in the Le Claire limestone. "In the midst of this was the impression of a large *Euomphalus* distinct from any known in the surrounding rocks and very similar to a Carboniferous form, x x. The conclusion seems therefore irresistible that subsequent to the uplifting of these rocks and their denudation, the materials of the coal measures were deposited upon the surface of the older rocks."* He cites several other instances. At Clinton these pockets of Carboniferous clay are frequent in the quarries at the bluff and in pits found in every direction where the rock is uncovered on the town plot. The crevices and cavities in the quarries were filled from the top about fifty feet above the present river. In one observed there was a chimney opening down to a large cavity, extending across the quarry, a hundred feet or more. There were also numerous smaller pits in the vicinity, in which the clay looked like cannel coal and had fragments of carbonized wood in it. The larger cavity was excavated for pottery clay. There were no fossils found except some pieces of pryritized wood. The darkest material put into the fire turned very red from the large portion of oxide of iron. A large deposit of this clay was found at the foot of another quarry.

My attention has been called several times to indications of supposed coal mines in the deep channels of streams that run into the river. Pits were filled with coal-like clay similar to that above described.

The openings of these crevices in the bluff are fifty or sixty feet above the river, 575 feet above sea level, say 635 feet.

This shale and a Carboniferous sandstone with traces of Carboniferous fossils have been traced into Jones county, twenty or thirty miles north. In fact it has been found in counties farther north. The flood-plain of the Mississippi at Clinton is 200 feet below the prairie level. A subsidence of a hundred feet would cover these deposits. At Rapids City, thirty miles below Clinton, coal is mined, its under-clay resting on the Niagara rock on a level with the flood-plain of the river. The subsidence of a hundred feet allowed the Carboniferous sea to flow up the river valley and cause the deposit of the Carboniferous material of that period. It is therefore obvious that the valley is pre-Glacial by a long period.

The record is much more ancient. It has been demonstrated that the original surface of Iowa was furrowed by deep channels and great denudation, probably in the Devonian age. Deep wells 300 feet or more in the drift, and mounds capped with the Niagara limestone near Dubuque and Galena, are evidences of the great erosion. The singular region called the driftless area in the corner of Iowa and Wisconsin, is probably a fair representation of the land surface of this middle west in Paleozoic times. This driftless portion is cut into conical hills 200, 300 and even 500 feet high, divided by ravines and canyons, the streams of which have cut channels down to the level of the Mississippi valley and have filled up fiords at their mouths of unknown depth. The drift has covered the rest of the country higher than these hills.

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*HALL'S Iowa Reports, vol. i, p. 130, 1858.

Spencer has demonstrated from the deep channels at the mouth of the St. Lawrence, traces in the gulf, and the continuation of the Hudson river in New York bay, and from other data, that the eastern part of the continent once was very greatly elevated, when its rivers cut deep canyons and fiords similar to the canyon of the present Colorado. Then a depression and submersion, out of which not all the coast was raised.

The evidences are that the interior of the continent was also elevated after the Devonian period, and was washed by great denuding and erosive floods. The Mississippi valley has survived as the great water way of succeeding ages, while others have been filled. This is the inference, to some extent, of Prof. Chamberlin, who says, "the course of the Mississippi river is along the shore of the Devonian sea.* The present channel of the Mississippi is from 100 to 200 feet above its ancient bed. A deep boring at La Crosse showed sand and loose material to the depth of 147 feet. Rock river at Janesville is at least 250 feet above its ancient valley." At Clinton soundings for the railroad bridge went through sand and gravel 80, 100 and 150 feet to the rock below the water. The ancient channel is the sand plain beyond and has been sounded for more than 200 feet. A buried ravine runs through the town plot of Clinton, which has been explored for foundations to the depth of 100 feet without reaching the bed rock. Prof. Chamberlin says, "the cutting down of the ravines in the driftless area began in the early Devonian age† and was evidently a period of elevation. A subsidence took place at the beginning of the Carboniferous period, and to such an extent as to make a lagoon or placid bayou of the river valley up to and beyond Dubuque. In this quiet water was deposited clay and vegetation that forms coal. Its depth was approximately a hundred feet. A moderate elevation ensued which brought the valley to its present level and the coal formation was swept away, excepting only the traces left in these fissures and pits.

The most interesting geological history of the Mississippi valley is yet to be written. It has only been touched on here and there. It was a great river on an elevated plateau on the Niagara in this vicinity, at the close of the Devonian period. It fell into the gulf of Mexico at the mouth of the Ohio. It cut a broad deep valley varying from two to ten miles wide. The river itself is wider where tributary rivers check the current. The valley grows somewhat narrower near Dubuque, above which it has the same depth but is somewhat more regular in its outline. It is thence a grand Niagara river gorge on a grand scale, to St. Paul.

The glacial era, at its close, left its marks on many places in the

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*Wisconsin reports, vol. i, p. 253.

†*Geology of Wisconsin*, vol. i, p. 153.

river valley. It was filled with ice to the prairie level. When the ice melted and the higher land appeared, the water cut new channels along the border in many places; notably at the upper and lower rapids, and further down. The "old father of waters," has not had sufficient time or force to deepen these channels. It is on these incomplete cuttings that the United States government is spending large sums of money. At the closing up of the ice-period many of the tributary streams also lost their old courses and cut new ones. This is the situation of many of the rivers of Iowa which has puzzled observers.
P. J. FARNSWORTH.

Clinton, Iowa, Oct. 12, 1901.

RECENT DECLINE IN THE LEVEL OF LAKE NICARAGUA.—About a year ago (October, 1900), Mr. J. Crawford published a letter in the American Geologist in which criticism is made of Dr. Heilprin's claim that the water-level in lake Nicaragua had fallen 20 feet between the years 1880 and 1898. In the course of his criticism Mr. Crawford says: "If between 1880 and 1898 there has been a decline of 20 feet from the 1880 level of lake Nicaragua from any cause, then the beach marks of the 1880 level would be easily found along the borders of the lake. But there is no such evidence to be found." While I have no data which would enable me to discuss the time-element in controversy, I did secure evidence, during my visit to Nicaragua in 1892-3, of a comparatively recent subsidence of the level of lake Nicaragua, and discussed it briefly in a paper published in 1896.*

It may be of interest, even at this late day, to quote the paper in question:

"The peculiar exposure of which notice is here made is found on the Manuel Vargas ranch, east of San Carlos, Nicaragua, on the south bank of the San Juan river. The river, here only twelve miles from the outlet of lake Nicaragua, flows due east and cuts into a terrace on the southern shore, forming a vertical bank which gradually rises from the low river-bottom at its eastern extremity, and reaches a height of more than fifteen feet at the western extremity of the shell-bearing portion. This bank, for one hundred yards from its eastern extremity, consists of fine alluvium which is literally packd with Unio shells, frequently cemented together by calcareous tufa into large masses.

"The shell-bearing portion of the exposure averages about twelve feet in height, but the surface of the ground gradually rises back from the river, and shells were traced along the surface to a point more than one hundred and fifty feet from the shore, this point being fifteen or twenty feet above the river which had then (March 12th, 1893) not yet reached its lowest stage. This indicates a total thickness of the deposit of more than fifteen, and probably not less than twenty feet.

"There are three species of *Unio* in the series of shells collected from the bank, and they are identical with living species found now in the mud of the river at the foot of the exposure. Many of the fossil shells still

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**Bull Lab. Nat. Hist., State Univ., Iowa*, vol. iv, pp. 94-95. A Nicaraguan Shell-bank.

have their valves united by the ligament, and not a few are in a vertical position, showing that the shells had been deposited *in situ*. These species are now found living in abundance in the river in the mud close to the shores, and the fossil shells no doubt were developed under similar conditions.

"The conclusion naturally follows that at one time the San Juan river and, of course, lake Nicaragua, of which it is the outlet, had their low water mark more than fifteen feet above the present level; that the river has since cut through the eastern barriers to its present level, in its downward progress gradually depositing an oblique sheet of shell-bearing alluvium; and that the level of the lake has correspondingly fallen. Lake Nicaragua is today more than one hundred feet above sea-level. The San Juan river therefore has sufficient fall for further effective erosion, which is, without doubt, going on at an increasing rate, and the conclusion seems irresistible that the lake is destined to a further reduction of its level, and a still further contraction of its area, and that within no distant future; since it is evident from the comparatively perfect preservation of the shells above mentioned that the whole shell-bank is a very recent affair indeed, as terrestrial changes go.

"In view of the attempted construction of vast public works along the valley of the San Juan river, the importance of this conclusion is sufficiently obvious.

"While the lake cannot be wholly drained, its greatest depth being about two hundred and forty feet and the elevation of its surface above sea level being one hundred and ten feet, its average depth is such that a comparatively slight fall in its general level must cause a great contraction of its area—a circumstance of much importance to the cities and towns along its shores.

"The building of the proposed great Ochoa dam across the lower San Juan river in connection with the construction of the Nicaragua canal is probably the only thing that would arrest this erosion, and would secure the retenton of this vast and important inland reservoir of fresh water."

All that part of the river valley lying above the point here discussed was evidently at no remote time covered by the waters of the lake which have since receded to San Carlos because of the lowering of the river channel and consequently of the lake level.

The deposit of shells here discussed is not to be compared with the shell heaps sometimes found along shores, but was evidently formed gradually, and represents an old Unio bed.

In considering the extent of the change in the altitude of the water-level in the lake, which is shown by this deposit, it must be borne in mind that to live Unios must be constantly submerged, and that therefore the highest portion of the shell-bank represents what at one time was less than the lowest stage of water in the lake. It is true that these Unios (fresh water mussels) are capable of creeping about more or less, but nowhere do whole colonies of them move upward with the floods, to be stranded when the waters again recede.

Whatever may be the exact dates or altitudes involved, it is certain that the waters of lake Nicaragua have subsided in comparatively recent years, and that the way to save lake Nicaragua is to construct the great canal. B. SHIMEK.

State University of Iowa, Nov. 25, 1901.

PERSONAL AND SCIENTIFIC NEWS.

DR. H. M. AMI, of the Geological Survey of Canada, who sustained a rather severe injury to hs left arm and shoulder last September, from a fall down the steep cliff at Cap à L'Aigle below Quebec City, is sufficiently recovered to resume his official duties at Ottawa.

DR. THOMAS L. WALKER, of the Geological Survey of India, and formerly lecturer in Toronto University, has been appointed professor of Mineralogy and Petrography in the same university. Authorities at Toronto University have not yet selected from the many candidates the man to fill the vacant chair of Geology and Paleontology.

GEOLOGICAL SOCIETY OF WASHINGTON. On November 13th the following program was presented: "Pyrite and Marcasite," H. N. Stokes; "The Geographic Features of New Mexico," R. T. Hill; "Occurrences of Petroleum in the Northern Rockies," Bailey Willis. The program for the meeting on Nov. 27th was devoted to "The Geology of Cuba," as follows: "Physiography," C. W. Hayes; "General geology and geologic history," T. W. Vaughan; "Economic Geology," A. C. Spencer.

LEHIGH UNIVERSITY is erecting a stone laboratory, 90 ft. by 43 ft. to be used in connection with the steam engineering work of the course in mechanical engineering. Next fall the university will offer a new and extended course in electro-metallurgy—the first of its kind, it is believed, to be established in this country. The departments of civil engineering and of geology have recently received valuable gifts in the shape of surveying instruments, microscopes, and geological specimens for the microscopic study of rocks.

IN NOVEMBER DR. J. W. SPENCER left Toronto with Mrs. Spencer to spend several months in Mexico and Central America, intending to return to Washington about May 1. The object of his travels is to make further investigation of the plateau forms, valleys and cañons for the purpose of comparison with the drowned features of the West Indian region. He had previously discovered the geological canal and the proof of a very late Pleistocene shallow water connection between the gulf of Mexico and the Pacific. It is over the isthmus of

Tehauntepec. The gravel plain of the floor is now raised up 800 feet. This canal is a mile long, 150 feet deep, and narrow, with its floor covered with rounded gravel, which merges into a terrace on the gulf side.

AN INTERESTING INTERCOLLEGIATE EXCURSION of teachers and advanced students, under the guidance of professor W. M. Davis, of Harvard University, was made on October 19th to the river terraces in the Westfield river valley, in Massachusetts. The particular aim was to work out the control of rock ledges upon the distribution and topography of the terraces. Forty-six persons were present, representing twelve institutions. The success of the trip has encouraged its promoters to hope for others in 1902, to bring together members of the various higher institutions of learning in New England.

THE FIELD WORK OF THE FIRST YEAR RESEARCH COURSE in geology at Harvard University, for this year, is an elaboration of that begun two years ago. At present eighteen men are engaged in a geological survey of the metropolitan district of Boston, including the Boston Basin and its surrounding igneous and sedimentary rocks. The members are acting as volunteer assistants on the U. S. Geological Survey, under Dr. T. A. Jagger, Jr., as a regular office of the survey; and the work, which is based upon recent detailed topographic mapping of the survey, is submitted with a view to ultimate publication by that organization, as folios or reports. The nine field parties cover territory stretching from Marblehead on the north to Nantasket on the south, and from the ocean west to Bedford and Dover.

GEOLOGICAL EXPLORATIONS NEAR ATHENS. The British Museum during the past summer has obtained some important fossils of tertiary mammals at Pikermi, near the Marathon road, about twelve miles from Athens. The specimens were found at a considerable depth below the bed of a mountain torrent, and were so jammed together that evidently the animals were buried alive, probably by torrential action. About fifty years ago Dr. Albert Gaudry in this locality obtained a great number of fossils for the Paris museum. Since then the Vienna academy has made a similar collection; but until the present year the British museum had sent no expedition to this field. Among the principal finds were numerous bones of *Hipparion, the* three-toed predecessor of the horse; *Helladotherium*, a short-necked giraffe allied to the *Okapi,* the new mammal recently discovered by Sir Henry Johnston in the forests of the Kongo state; several skulls of *Mastodon,* and skulls, teeth and bones of the great saber-toothed tiger *Machaerodus*, specimens of which have been found in England. One of the prizes was the remains of perhaps the largest tortoise ever found in Europe. Very few bones of rodents or of birds were found, but a considerable collection of land shells was obtained. Dr. A. S.

Woodward, who was in charge of the excavation, has forwarded to the British museum forty-seven large cases of fossils.—*Nat. Geog. Mag.*

I HAVE BEEN UNABLE TO OBTAIN positive proof of the discovery of any implements used by man in gravels covered by so-called lavas, or human remains in auriferous deposits in place in any part of California. I have for years kept this matter in view and eagerly sought information when discoveries were announced, but have met with an insurmountable doubt when the evidence was carefully investigated. The same uncertainty applies to discoveries made at the bottom of vertical shafts, for surface objects may accidentally fall or be thrown into them purposely. H. G. HANKS.

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